

QUALITY ASSURANCE PROJECT PLAN  
Wilcox Oil Company Superfund Site  
Bristow, Oklahoma

Revision 1

Prepared for:  
United States Environmental Protection Agency/Environmental Response Team  
Edison, New Jersey

By:  
Lockheed Martin/Scientific, Engineering, Response and Analytical Services  
Work Assignment Number: SERAS-277

November 24, 2015

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**QAPP Worksheet #1**  
**Title and Approval Page**

**Site Name/Project Name:** Wilcox Oil Company Superfund Site  
**Site Location:** Bristow, Oklahoma (OK)

*Document Title:* Quality Assurance Project Plan (QAPP) for Wilcox Oil Company Superfund Site – December 2015 Mobilization – Cone Penetrometer Testing/Rapid Optical Screening Technology (CPT/ROST) Investigation

*Lead Organization:* Environmental Protection Agency/Environmental Response Team (EPA/ERT)

*Preparer's Name and Organizational Affiliation:* Jon McBurney - Lockheed Martin/Scientific Engineering Response and Analytical Services (SERAS)

*Preparer's Address, Telephone Number, and E-mail Address:* 2890 Woodbridge Avenue, Edison NJ 08837, (732)494-4060, jonathan.d.mcburney@lmco.com

*Preparation Date (Day/Month/Year):* 11/24/15

Investigative Organization's Project Manager/Date: \_\_\_\_\_  
Signature

Printed Name/Organization: Tom Kady/ERT Work Assignment Manager

Investigative Organization's Project QA Officer/Date: \_\_\_\_\_  
Signature

Printed Name/Organization: Stephen Blaze/ERT Quality Coordinator

Lead Organization's Project Manager/Date: \_\_\_\_\_  
Signature

Printed Name/Organization: Jon McBurney/SERAS Task Leader

Approval Signatures/Date: \_\_\_\_\_  
Signature

Printed Name/Title: Deborah A. Killeen/SERAS QA/QC Officer

Approval Authority: Lockheed Martin/SERAS

Other Approval Signatures/Date: \_\_\_\_\_  
Signature

Printed Name/Title: Kevin Taylor/SERAS Program Manager

Document Numbering System: SERAS-277-DQAPPR1-112415

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**QAPP Worksheet #2**  
**QAPP Identifying Information**

**Site Name/Project Name:** Wilcox Oil Company Superfund Site

**Site Location:** Bristow, OK

**Site Number/Code:** EPA ID# OK0001010917

**Operable Unit:** NA

**Contractor Name:** Lockheed Martin

**Contractor Number:** EP-W-09-031

**Contract Title:** SERAS

**Work Assignment Number:** SERAS-277

1. Identify regulatory program: Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

2. Identify approval entity: EPA/ERT

3. The QAPP is (select one):            ☐Generic                            ☒Project Specific

4. List dates of scoping sessions that were held: 08/03/15, 11/6/15

5. List dates and titles of QAPP documents written for previous site work, if applicable:

Title	Approval Date
Quality Assurance Project Plan - Wilcox Refinery and Tank Farm Site, Bristow, Oklahoma SERAS-277-DQAPP-090915	9/9/2015

6. List organizational partners (stakeholders) and connection with lead organization:  
EPA Region 6

7. List data users:  
ERT, EPA Region 6

8. If any required QAPP elements and required information are not applicable to the project, then circle the omitted QAPP elements and required information on the attached table. Provide an explanation for their exclusions below:

WS #37 - Usability of the data will be assessed by EPA Region 6 personnel.

**QAPP Worksheet #2**  
**QAPP Identifying Information**  
**(continued)**

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Documents
<b>Project Management and Objectives</b>		
2.1 Title and Approval Page	- Title and Approval Page	1
2.2 Document Format and Table of Contents 2.2.1 Document Control Format 2.2.2 Document Control Numbering System 2.2.3 Table of Contents 2.2.4 QAPP Identifying Information	- Table of Contents - QAPP Identifying Information	2
2.3 Distribution List and Project Personnel Sign-Off Sheet 2.3.1 Distribution List 2.3.2 Project Personnel Sign-Off Sheet	- Distribution List - Project Personnel Sign-Off Sheet	3 4
2.4 Project Organization 2.4.1 Project Organizational Chart 2.4.2 Communication Pathways 2.4.3 Personnel Responsibilities and Qualifications 2.4.4 Special Training Requirements and Certification	- Project Organizational Chart - Communication Pathways - Personnel Responsibilities and Qualifications Table - Special Personnel Training Requirements Table	5 6 7 8
2.5 Project Planning/Problem Definition 2.5.1 Project Planning (Scoping) 2.5.2 Problem Definition, Site History, and Background	- Project Planning Session Documentation (including Data Needs tables) - Project Scoping Session Participants Sheet - Problem Definition, Site History, and Background - Site Maps (historical and present)	9 10
2.6 Project Quality Objectives and Measurement Performance Criteria 2.6.1 Development of Project Quality Objectives Using the Systematic Planning Process 2.6.2 Measurement Performance Criteria	- Site-Specific PQOs - Measurement Performance Criteria Table	11 12

**QAPP Worksheet #2**  
**QAPP Identifying Information**  
 (continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Documents
2.7 Existing Data Evaluation	<ul style="list-style-type: none"> <li>- Sources of Existing Data and Information</li> <li>- Existing Data Criteria and Limitations Table</li> </ul>	13
2.8 Project Overview and Schedule	- Summary of Project Tasks	14
2.8.1 Project Overview	- Reference Limits and Evaluation Table	15
2.8.2 Project Schedule	- Project Schedule/Timeline Table	16
<b>Measurement/Data Acquisition</b>		
3.1 Sampling Tasks	- Geophysical Sampling Design and Rationale	17
3.1.1 Sampling Process Design and Rationale	- Sample Location Map	
3.1.2 Sampling Procedures and Requirements	- Geophysical Sampling Locations and Methods/SOP Requirements Table	18
3.1.2.1 Sampling Collection Procedures	- Analytical Methods/SOP Requirements Table	19
3.1.2.2 Sample Containers, Volume, and Preservation	- Field Quality Control Sample Summary Table	20
3.1.2.3 Equipment/Sample Containers Cleaning and Decontamination Procedures	- Sampling SOPs	
3.1.2.3 Field Equipment Calibration, Maintenance, Testing, and Inspection Procedures	- Project Sampling SOP References Table	21
3.1.2.4 Supply Inspection and Acceptance Procedures	- Field Equipment Calibration, Maintenance, Testing, and Inspection Table	22
3.1.2.6 Field Documentation Procedures		
3.2 Analytical Tasks	- Analytical SOPs	
3.2.1 Analytical SOPs	- Analytical SOP References Table	23
3.2.2 Analytical Instrument Calibration Procedures	- Analytical Instrument Calibration Table	24
3.2.3 Analytical Instrument and Equipment Maintenance, Testing, and Inspection Procedures	- Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table	25
3.2.4 Analytical Supply Inspection and Acceptance Procedures		

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**QAPP Identifying Information**  
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<b>Required QAPP Element(s) and Corresponding QAPP Section(s)</b>	<b>Required Information</b>	<b>Crosswalk to Required Documents</b>
3.3 Sample Collection Documentation, Handling, Tracking, and Custody Procedures 3.3.1 Sample Collection Documentation 3.3.2 Sample Handling and Tracking System 3.3.3 Sample Custody	- Sample Collection Documentation Handling, Tracking, and Custody SOPs - Sample Container Identification - Sample Handling Flow Diagram - Example Chain-of-Custody Form and Seal	26 27
3.4 Quality Control Samples 3.4.1 Sampling Quality Control Samples 3.4.2 Analytical Quality Control Samples	- QC Samples Table - Screening/Confirmatory Analysis Decision Tree	28
3.5 Data Management Tasks 3.5.1 Project Documentation and Records 3.5.2 Data Package Deliverables 3.5.3 Data Reporting Formats 3.5.4 Data Handling and Management 3.5.5 Data Tracking and Control	- Project Documents and Records Table - Analytical Services Table - Data Management SOPs	29 29
<b>Assessment/Oversight</b>		
4.1 Assessments and Response Actions 4.1.1 Planned Assessments 4.1.2 Assessment Findings and Corrective Action Responses	- Assessments and Response Actions - Planned Project Assessments Table - Audit Checklists - Assessment Findings and Corrective Action Responses Table	31 32
4.2 QA Management Reports	- QA Management Reports Table	33
4.3 Final Project Report		

**QAPP Worksheet #2**  
**QAPP Identifying Information**  
 (continued)

Required QAPP Element(s) and Corresponding QAPP Section(s)	Required Information	Crosswalk to Related Documents
<b>Data Review</b>		
5.1 Overview		
5.2 Data Review Steps	- Verification (Step I) Process Table	34
5.2.1 Step I: Verification		
5.2.2 Step II: Validation	- Validation (Steps IIa and IIb) Process Table	35
5.2.2.1 Step IIa Validation Activities		
5.2.2.2 Step IIb Validation Activities	- Validation (Steps IIa and IIb) Summary Table	36
5.2.3 Step III: Usability Assessment		
5.2.3.1 Data Limitations and Actions from Usability Assessment	- Usability Assessment	NA
5.2.3.2 Activities		
5.3 Streamlining Data Review		
5.3.1 Data Review Steps To Be Streamlined		
5.3.2 Criteria for Streamlining Data Review		
5.3.3 Amounts and Types of Data Appropriate for Streamlining		

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### QAPP Worksheet #3 Distribution List

QAPP Recipients	Title	Organization	Telephone Number	Fax Number	E-mail Address	Document Control Number
Tom Kady	Work Assignment Manager (WAM)	ERT	(732) 906-6172	(732) 321-6724	<a href="mailto:kady.thomas@epa.gov">kady.thomas@epa.gov</a>	SERAS-277-DQAPPR1-112415
Stephen Blaze	Quality Coordinator	ERT	(732) 906-6921	(732) 321-6724	<a href="mailto:blaze.stephen@epa.gov">blaze.stephen@epa.gov</a>	SERAS-277-DQAPPR1-112415
Mike Hoppe	Technical Advisor	ERT	(732) 906-6908	(732) 321-6724	<a href="mailto:Hoppe.michael@epa.gov">Hoppe.michael@epa.gov</a>	SERAS-277-DQAPPR1-112415
Jon McBurney	Task Leader (TL)/ Project Engineer	SERAS	(732) 321-4244	(732) 494-4021	<a href="mailto:Jonathan.d.mcburney@lmco.com">Jonathan.d.mcburney@lmco.com</a>	SERAS-277-DQAPPR1-112415
Deborah Killeen	Quality Assurance/ Quality Control (QA/QC) Officer	SERAS	(732) 321-4245	(732) 494-4021	<a href="mailto:deborah.a.killeen@lmco.com">deborah.a.killeen@lmco.com</a>	SERAS-277-DQAPPR1-112415
Richard Leuser	Deputy Program Manager (DPM)	SERAS	(732) 494-4060	(732) 494-4021	<a href="mailto:richard.m.leuser@lmco.com">richard.m.leuser@lmco.com</a>	SERAS-277-DQAPPR1-112415
Kevin C. Taylor	Program Manager	SERAS	(732) 321-4202	(732) 494-4021	<a href="mailto:kevin.c.taylor@lmco.com">kevin.c.taylor@lmco.com</a>	SERAS-277-DQAPPR1-112415

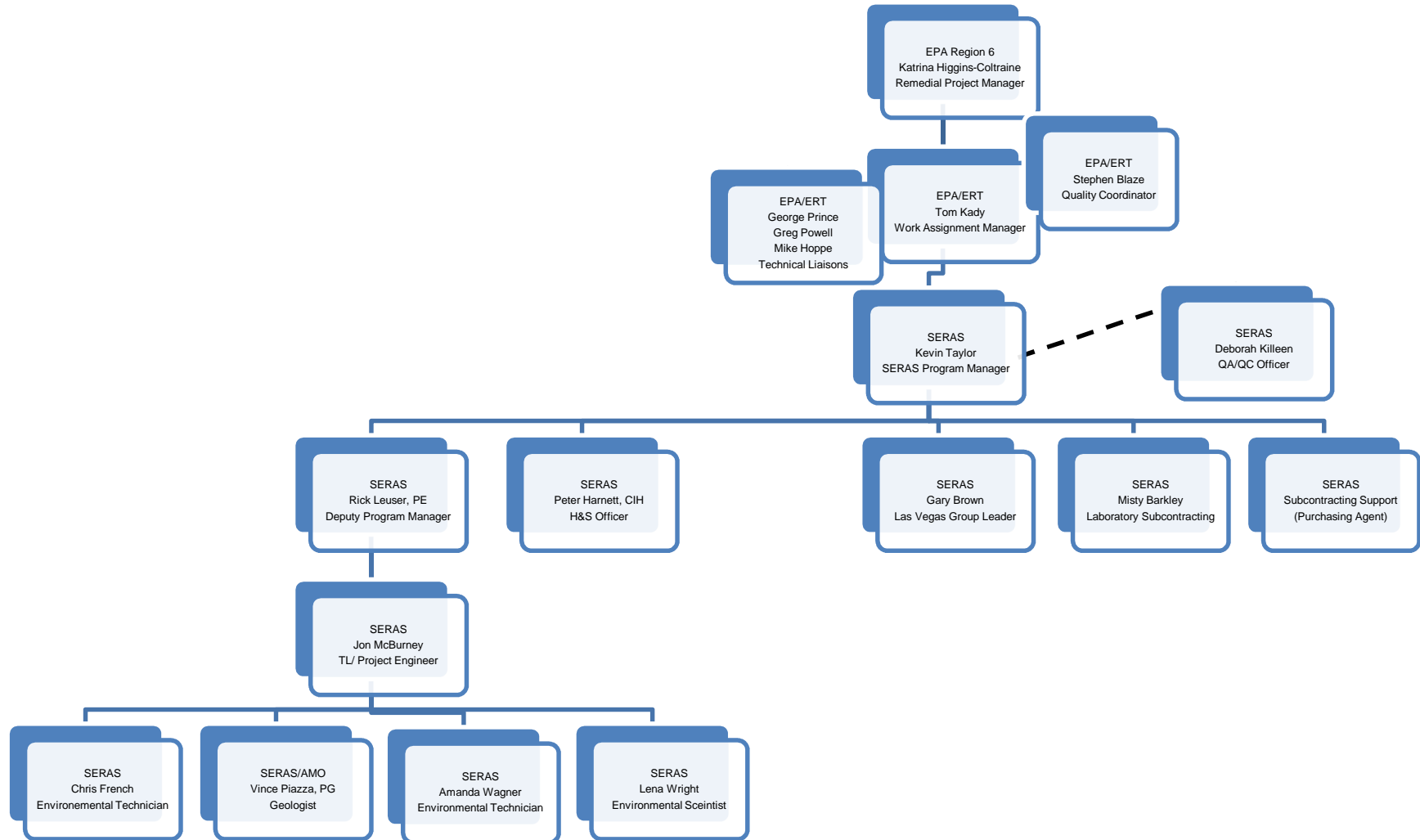
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**QAPP Worksheet #4**  
**Project Personnel Sign-Off Sheet**

**Organization:** SERAS/ERT/EPA

<b>Project Personnel</b>	<b>Title</b>	<b>Telephone Number</b>	<b>Signature</b>	<b>Date QAPP Read</b>
Jon McBurney	SERAS TL	732-321-4244		
Vince Piazza	AMO Geologist	215-230-8282		
Chris French	SERAS Environmental Technician	732-494-4040		
Tom Kady	ERT WAM	732-906-6172		
Katrina Higgins-Coltrain	EPA R6 Remedial Project Manager (RPM)	214-665-8143		
George Prince	ERT Technical Liaison	732-321-6649		
Greg Powell	ERT Technical Liaison	513-569-7533		
Mike Hoppe	ERT Technical Liaison	732-906-6908		
Lena Wright	SERAS Environmental Scientist	702-784-8035		
Amanda Wagner	SERAS Environmental Scientist	702-784-8043		

### QAPP Worksheet #5 Project Organizational Chart



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**QAPP Worksheet #6**  
**Communication Pathways**

<b>Communication Drivers</b>	<b>Responsible Entity</b>	<b>Name</b>	<b>Phone Number</b>	<b>Procedure (Timing, Pathways, etc.)</b>
Approval of initial QAPP and any amendments	ERT WAM ERT Quality Coordinator SERAS Program Manager SERAS QA/QC Officer SERAS TL	Tom Kady Stephen Blaze Kevin Taylor Deborah Killeen Jon McBurney	732-906-6172 732-906-6921 732-321-4202 732-321-4245 732-321-4244	SERAS internal peer review, followed by ERT approval, implementation of changes effective only with approved QAPP or QAPP Change Form
Nonconformance and Corrective Actions	SERAS TL ERT WAM SERAS DPM SERAS QA/QC Officer	Jon McBurney Tom Kady Rick Leuser Deborah Killeen	732-321-4244 732-906-6172 732-494-4060 732-321-4245	Use of the Work Assignment Field Change Form for field issues
Posting of Deliverables to ERT-Information Management System (IMS) website	SERAS TL SERAS QA/QC Officer SERAS Administrative Support SERAS Deputy Program Manager	Jon McBurney Deborah Killeen Eileen Ciambotti Rick Leuser	732-494-4244 732-321-4245 732-321-4255 732-494-4060	As per work assignments, posting of deliverables to ERT-IMS website constitutes delivery to the WAM.
Projected Work Assignment/Analytical Services Resource Requirements (PWA/ASRR)	SERAS TL	Jon McBurney	732 321-4244	Filled out by the SERAS TL upon receipt of the work assignment and following the project scoping meeting, and distributed to field, analytical, and support personnel.
Work Assignment	SERAS Program Manager	Kevin Taylor	732-321-4202	Describes scope of work to SERAS personnel from the ERT WAM.
Health and Safety On-Site Meeting	SERAS TL or Site Health and Safety Officer	Jon McBurney	732-321-4244	Explains site hazards, site specific safety and emergency procedures, personel protective equipment, directions to local hospital.

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**QAPP Worksheet #7**  
**Personnel Responsibilities and Qualification Table**

<b>Name</b>	<b>Title</b>	<b>Organizational Affiliation</b>	<b>Responsibilities</b>	<b>Education and Experience Qualifications</b>
Jon McBurney	Project Engineer/TL	SERAS	TL, Project Supervision, Reporting, Document Preparation	Minimum B.S. degree plus 14 years of related experience/Lockheed Martin Employee Files
Kevin Taylor	Program Manager	SERAS	Program Oversight	Minimum B.S. degree plus 14 years of related experience/LM Employee Files
Richard Leuser	DPM	SERAS	Technical Support and Oversight	Minimum B.S. degree plus 8 years of related experience/Lockheed Martin Employee Files
Vince Piazza	Geologist	SERAS/AMO	Field Activities/ Core Logging	B.S. Degree with 24 years of experience/AMO Employee Files
Deborah Killeen	QA/QC Officer	SERAS	Quality Assurance Oversight/ Deliverable Review	Minimum B.S. degree plus 14 years of related experience/Lockheed Martin Employee Files
Christopher French	Environmental Technician	SERAS	Field Activities	Related experience in environmental sampling/field activities/Lockheed Martin Employee Files
Tom Kady	WAM	ERT	Technical Direction	EPA job-related qualifications/EPA Files
George Prince	Co-WAM	ERT	Technical Direction	EPA job-related qualifications/EPA Files
Peter Harnett	Health and Safety Officer	SERAS	Health and Safety Plan (HASP) Review, PPE Selection, Health & Safety (H&S) Oversight	Minimum B.S. degree plus 14 years of related experience/LM Employee Files
Stephen Blaze	Quality Coordinator	ERT	QA Oversight	EPA job-related qualifications/EPA Files
Katrina Higgins-Coltrain	RPM	EPA R6	Project Oversight	EPA job-related qualifications/EPA Files
Lena Wright	Environmental Scientist	SERAS	FP XRF Operation	Minimum B.S. Degree with 3 yrs. related experience/ Lockheed Martin Employee Files
Amanda Wagner	Environmental Scientist	SERAS	Field Activities	Minimum B.S. Degree with 3 yrs. related experience/ Lockheed Martin Employee Files

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**QAPP Worksheet #8**  
**Special Personnel Training Requirements Table**

<b>Project Function</b>	<b>Specialized Training – Title or Description of Course</b>	<b>Training Provider</b>	<b>Training Date</b>	<b>Personnel/Groups Receiving Training</b>	<b>Personnel Titles/ Organizational Affiliation</b>	<b>Location of Training Records/Certificates</b>
Project Oversight	40 hour Health and Safety training with 8-hour Refresher	SERAS	Dec 2014	Jon McBurney	TL/SERAS	SERAS Health & Safety Files
Field Activities	40 hour Health and Safety training with 8-hour Refresher	SERAS	June 2015	Vince Piazza	Professional Geologist/AMO	AMO Health & Safety Files
QA Oversight	Uniform Federal Policy for Quality Assurance Project Plans	Advanced Systems	Jan 2006	Deborah Killeen	QA/QC Officer/SERAS	SERAS Quality Files
Field Activities	40 hour Health and Safety training with 8-hour Refresher	SERAS	Nov 2014	Christopher French	Environmental Technician/ SERAS	SERAS Health & Safety Files
Field Activities	40 hour Health and Safety training with 8-hour Refresher	SERAS	Nov 2015	Amanda Wagner	Environmental Scientist/ SERAS	SERAS Quality Files
Field XRF Analysis –Niton	Demonstration of Capability	SERAS	Nov 2015	Lena Wright	Environmental Scientist/ SERAS	SERAS Quality Files
Field XRF Analysis	40 hour Health and Safety training with 8-hour Refresher	SERAS	Nov 2015	Lena Wright	Environmental Scientist/ SERAS	SERAS Quality Files

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**QAPP Worksheet #9-1**  
**Project Scoping Session Participants Sheet**

<b>Project Name: Wilcox Refinery Superfund Site</b>		<b>Site Name: Wilcox Refinery Superfund Site</b>			
<b>Projected Field Work Date(s): 14-29 Sept. 2015</b>		<b>Site Location: 1 mile Northeast of Bristow, Oklahoma</b>			
<b>Project Manager: Richard Leuser</b>					
<b>Date of Session: August 3, 2015</b>					
<b>Scoping Session Purpose: Scoping meeting to discuss field work</b>					
<b>Name</b>	<b>Title</b>	<b>Affiliation</b>	<b>Phone #</b>	<b>E-mail Address</b>	<b>Project Role</b>
Tom Kady	WAM	ERT	732-906-6172	<a href="mailto:kady.thomas@epa.gov">kady.thomas@epa.gov</a>	Technical Direction
Rick Leuser	TL/DPM	SERAS	732-494-4060	<a href="mailto:richard.m.leuser@lmco.com">richard.m.leuser@lmco.com</a>	Project Oversight
Beth Williams	Sr. Geophysicist	SERAS	717-649-5291	<a href="mailto:bwilliams@amoed.com">bwilliams@amoed.com</a>	Operation of Geophysical Equipment/ Data Reduction/Interpretation
Deb Killeen	QA/QC Officer	SERAS	732-321-4245	<a href="mailto:deborah.a.killeen@lmco.com">deborah.a.killeen@lmco.com</a>	QA Oversight
Chris French	Environmental Technician	SERAS	732-494-4040	<a href="mailto:christopher.m.french@lmco.com">christopher.m.french@lmco.com</a>	Site Management & Support

Notes:

- Bedrock at the site is shallow, thereby limiting the use of Cone Penetrometry (CPT).
- Sequence of this investigation will be Geophysical investigation and Potholing, followed by CPT.
- Geophysical investigation will be begin on September 14, 2015 and run for two weeks max.
- This will investigate the seeping petroleum sludges downhill from the bermed and apparent source areas as far as it can be followed, using the EM-31 to determine the signature of the petroleum sludge. If this works, each bermed location will be investigated to determine whether there are other below ground seeps not yet identified.
- GPR will be used to map the bedrock surface. No seismic studies are planned at this time.
- Site mobilization and equipment/jobsite requirements were identified.
- Williams has a pipeline across the property. They must be notified and identify the location of the line.
- Subsurface pipelines and structures, concrete, tanks, etc. will be identified, geolocated and marked, then added to the site drawing.
- Tom will provide numerous maps to consolidate into one Georeferenced map.
- Goals include:
  - Wilcox Refinery
    - Clear for subsurface utilities and structures.
    - Find signature for petroleum sludge flows.
    - Check for additional flows/plumes.
  - Lorraine Refinery
    - Clear and grub if/as necessary.
    - Clear property for underground obstructions.
  - Wilcox Tank Farm
    - Try the Electromagnetic (EM)-31 and ground penetrating radar (GPR) but these may not work here.

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- Pothole as necessary to determine whether sludge flows are present.
  - Scope out the potential for the use of CPT later based on findings. Also possibly membrane interface probe (MIP) and Geoprobe.
  - For future work will likely use CPT and Geoprobe/MIP. Can rent Geoprobe.
- August activities include:
  - Finalize Work Plan (WP)
  - Finalize QAPP and obtain approval.
  - Update HASP for planned work through CPT and Geoprobe.
  - Arrange for equipment, trailer, port a jon, etc.
  - Water may be available onsite at hydrant. Check on this.
- September activities include:
  - Mobilize for September 14, 2015.
  - Site Mob includes Williams Trailer with A/C.
  - Check Power onsite.
  - Equipment to site includes
    - Small Track Excavator
    - Bobcat w/bush hog.
    - Mule
    -
- October activities
  - Mobilize-Trailer and infrastructure still in place from September.
  - Geoprobe w/MIP.
  - CPT Contractor
  - Mule
  - Bobcat & Excavator may remain, TBD.
  - Est. Duration three (3) weeks.

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**QAPP Worksheet #9-2**  
**Project Scoping Session Participants Sheet**

<b>Project Name: Wilcox Refinery Superfund Site</b>			<b>Site Name: Wilcox Refinery Superfund Site</b>		
<b>Projected Field Work Date(s): 1 – 15 Dec 2015</b>			<b>Site Location: 1 mile Northeast of Bristow, Oklahoma</b>		
<b>Project Manager: Richard Leuser</b>					
<b>Date of Session: 11/6/15</b>					
<b>Scoping Session Purpose: Scoping meeting to discuss field work</b>					
Name	Title	Affiliation	Phone #	E-mail Address	Project Role
Tom Kady	WAM	ERT	732-906-6172	<a href="mailto:kady.thomas@epa.gov">kady.thomas@epa.gov</a>	Technical Direction
Rick Leuser	TL/DPM	SERAS	732-494-4060	<a href="mailto:richard.m.leuser@lmco.com">richard.m.leuser@lmco.com</a>	Project Oversight
George Prince	ERT Technical Liaison	ERT	732-321-6649	<a href="mailto:george.prince@epa.gov">george.prince@epa.gov</a>	Technical Direction
Katrina Higgins-Coltrain	RPM	EPA	214-665-8143	<a href="mailto:katrina.coltrain@epa.gov">katrina.coltrain@epa.gov</a>	Remedial Project Manager
Todd Downham	State Representative	OK DEQ	405-702-5136	<a href="mailto:Todd.downham@deq.ok.gov">Todd.downham@deq.ok.gov</a>	State Liason
Amy Brittain	State Representative	OK DEQ	405-702-5157	<a href="mailto:Amy.brittain@deq.ok.gov">Amy.brittain@deq.ok.gov</a>	State Liason

Notes:

Review QAPP

Prioritize

Punch List, Pre-planning

The most important issue is pathways to the creek and contamination in the creek.

Priorities:

1. Where are the pathways and are they still active?
  - a. Walk the creek line and look for surface water pathways or seep pathways. Then use CPT to investigate those areas.
  - b. Area of catastrophic release by surface water from berm that was broken.
2. Tank farm investigation – Define the tank farm area. Show that there is exposure or risk to properties from tank farm.
3. Where is the LNAPL still on site (horizontal and vertical extents)? Primarily in the area of the Church's Well (Lorraine Property).
4. If seeps are found, investigate by Geoprobe and by CPT/ROST.
5. South to North on Wilcox property. Perimeter sampling around operations areas. Where contaminant types match, preliminary pathways can be theorized.
6. North of Refinery Road and two suspect tanks (far eastern end of property) are last priorities, optional if time permits.

Equipment:

1. Brush Hog

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2. Excavator with dozer blade for regrading ruts, etc.

Contractors:

1. CPT/ROST
2. Geoprobe
3. Utility Markout
4. 3D Modeler

Complaints from residents regarding regrading of excavations. "Dirt was piled high with ruts".

Must do One-Call. Double check with Utility mark out company. Tom to call Church Pastor (Mark Evans) to allow for interior access to chase utilities. Williams Pipeline, possible Sunoco Pipelines. Jon to talk to Tom regarding phone numbers.

Holes must be filled after investigations.

Communications with residents must be kept up.

Outside decision makers. Setup status late day call for updating decision makers. Maybe 4:00 pm calls.

Access Issues:

1. Working in Electrical Overhead right of way.

Action Items:

1. Oklahoma One Call
2. Williams Pipeline, other Pipelines
3. Church Pastor
4. Tom to send email with info regarding the 4Dim viewer.
5. Need to set up share point site for data sharing. Public side for tribe access.
6. Add full list of XRF analytes to QAPP. (Pb, As, Cr, Hg especially)
7. Next Call week of 16<sup>th</sup> of November. Probably Wed or Thurs.

Schedule:

Arrive Monday, 11/30. Rigs arrive 12/1. Work straight through to 12/15 or 12/16. CPT/XRF every day. Geoprobe maybe Saturday.

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## **QAPP Worksheet #10**

### **Problem Definition**

**The problem to be addressed by the project:**

The Site consists of the former Lorraine/Wilcox Refinery located in Creek County, OK. The property was used by two different refineries with overlapping boundaries from 1915 to 1965. Wilcox operated as a crude oil refinery from the 1920s to 1963. A skimming and cracking plant was constructed in 1929. The main components of the plant consisted of a skimming plant, cracking unit and re-distillation battery with a vapor recovery system and treatment equipment. Wilcox expanded when it acquired the Lorraine Refinery in 1937, which was located adjacent to Wilcox. The two refineries comprise 125 acres. The Site includes remnants of former oil refining operations and tank farms. There are 7 residential properties on the Site. Two properties are located within the former process area while the remaining 5 are located within the storage tank areas. The refinery waste source areas of concern include a backfilled oily waste pond and pit, a breached settling pond, a former pond apparently backfilled with solid refinery waste, and a number of former tank storage areas. The contaminants of concern are metals and organic compounds (Total Petroleum Hydrocarbons (TPH) and Polycyclic Aromatic Hydrocarbons (PAHs)). These potential contaminants of concern are found in soil, sediment, and waste material.

In a previous mobilization, SERAS personnel conducted a geophysical survey of the site to locate abandoned underground oil tanks and piping within the limits of the Wilcox Oil Company Superfund Site. In addition, the bedrock underlying the tank farm was mapped to show depth to bedrock and potential pathways of migration for contaminants.

SERAS personnel have now been tasked with investigating the site using in-situ methods such as CPT and ROST using laser induced fluoroscopy (LIF), as well as more conventional methods such as direct sampling using direct push technology (DPT) such as Geoprobe™ with conventional sampling. Field XRF will also be used to help guide the sampling investigation.

A conceptual site model (CSM) will be built to be able to conduct a more focused remedial investigation (RI) effort.

**The environmental questions being asked:**

Previously:

What is the bedrock topography?

Are direct-push, direct-sensing technologies viable in this area?

Does the bedrock topography create preferential pathways?

What types of subsurface structures and utilities exist (i.e., foundations, piping, underground storage tanks (USTs))?

For this mobilization, there are several questions, depending on the area of the site.

Tank Farm Area

What is the variety of waste streams found in the tank farm area?

Are any of the waste streams of a leachable nature that could impact groundwater (GW) or nearby streams?

What oil-related material was used to assist with the construction of the berms?

What is the extent of the tarry waste?

What wastes remain in the ponds?

Is there risk to the public/environment from the contamination at this site?

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Do surface and/or subsurface migration pathways exist from the tank farm area to the creeks?

**Environmental Questions (Cont.)**

Refinery Areas (Wilcox Refinery [WR] Area and Lorraine Refinery [LR] Area)

What are the variety of wastes remaining in the refinery area?

Are there any additives remaining?

Is there risk to the public/environment from the contamination at this site?

Do surface and/or subsurface migration pathways exist from the refinery areas to the creeks?

Site Boundaries and Creeks

Are site contaminants related to the oils and other wastes materials found in the creek nearby and/or downstream?

**Observations from any site reconnaissance reports:**

Two seeps are present along the creek which is an indication of migration of contaminants.

**A synopsis of existing data or information from site reports:**

There are currently several Light Detection and Ranging (LIDAR) photographs that have been provided by the RPM and additional information has been requested. Site sampling has occurred several times in the past twenty years. Worksheet 13 identifies these activities and their reports.

**The possible classes of contaminants and the affected matrices:**

Crude oil and possibly refinery products and intermediaries in soils and GW will be measured by gasoline range organics (GRO), diesel range organics (DRO) and oil range organics (ORO).

Metals (including cyanide [CN] and mercury [Hg], volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and pesticides in soils and GW.

Hexavalent chromium (CrVI) and tetra-ethyl lead (TEL) will be analyzed in soils and GW based on field lead and chromium results. TEL is a direct additive to boost the octane rating of gasoline.

**The rationale for inclusion of chemical and nonchemical analyses:**

All analyses were chosen based on the variety of activities that may have occurred at the refinery. It is unknown what waste streams were generated or what materials may have been leaked or dumped. Due to this uncertainty, a wide range of analytes has been chosen.

**Information concerning various environmental indicators:**

Visible petroleum sludges appear to be flowing downhill from the original tank farm locations. Initial sampling by the State of Oklahoma has confirmed the presence of these sludges above and below ground surface. Berms around historic tank locations indicate an oil related component to their makeup. Settling ponds are visible and based on operational understanding, would contain possible petroleum byproducts. A noticeable "dead zone" where plants are not growing has been noted and could indicate contamination.

**Project decision conditions ("If..., then..." statements):**

If contamination is located on the site, then a decision will be made by EPA Region 6 whether or not to remediate.

If contamination on site is found to be similar to contamination found in the adjacent creeks, then fingerprinting of on-site wastes versus wastes located in the creek may be performed.

If significant wastes are located, then a further more refined remedial investigation may be required.

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**QAPP Worksheet #11**  
**Project Quality Objectives /Systematic Planning Process Statements**

<b>Who will use the data?</b> ERT and EPA Region 6.
<b>What will the data be used for?</b> Data will be used to begin construction of a CSM and to guide future focused RI activities.
<b>What type of data is needed?</b> Data required for this site are as follows: <ol style="list-style-type: none"><li>1. In-situ measurement of tip pressure, sleeve friction and corresponding soil type by CPT SOPs.</li><li>2. In-situ hydrocarbon screening using ROST</li><li>3. Geologic logging of cores collected by DPT sampling by a Professional Geologist.</li><li>4. Field measurement of metals by field portable XRF (Full XRF analyte list, see Worksheet 15-16). Depth of XRF reading will be noted in the XRF sample log.</li><li>5. Field screening of cores with a MultiRAE tool for VOCs. Depth of PID readings will be noted in the Geologic Core Log.</li><li>6. Soil samples from cores will be sent to the CLP laboratory for VOCs, SVOCs, Metals (incl. Cn and Hg), PCBs and Pesticides</li><li>7. Soil samples from cores will be sent to a SERAS subcontract laboratory for GRO, DRO, and ORO.</li><li>8. Water samples from temporary wells will be sent to the CLP laboratory for VOCs, SVOCs, Metals (incl. Cn and Hg), PCBs and Pesticides</li><li>9. Soil samples from cores may be sent for CrVI and/or TEL to a SERAS subcontract laboratory.</li><li>10. GW samples from temporary wells will be sent for CrVI and/or TEL to a SERAS subcontract laboratory.</li><li>11. Global positioning system (GPS) and elevation data will be collected for each CPT/ROST and DPT position for later modeling.</li></ol>
<b>How “good” do the data need to be in order to support the environmental decision?</b> <ol style="list-style-type: none"><li>1. All CPT/ROST data will be considered screening data.</li><li>2. Field XRF and MultiRAE measurements will be considered screening data.</li><li>3. VOCs, SVOCs, Metals (inc. CN and Hg), PCBs, Pesticides will be considered definitive data for use in risk assessment.</li><li>4. DRO/ORO/GRO will be considered screening data.</li><li>5. CrVI and TEL data will be used for risk assessment and must be definitive data.</li><li>6. GPS and elevation data will be considered screening data.</li></ol>

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**How much data are needed? (number of samples for each analytical group, matrix, and concentration)**

1. CPT/ROST data will be collected for a period of a minimum of 10 days using two separate rigs. The total number of locations will be determined in the field based on other CPT/ROST results.
2. DPT core sampling will be completed as determined in the field based on the CPT/ROST results.
3. Approximately five field XRF measurements will be collected for each DPT core.
4. Each core will be screened with a MultiRAE tool for possible VOCs.
5. Up to 100 soils samples will be submitted for VOCs, SVOCs, and Metals analyses.
6. Up to 10 soil samples will be submitted for PCBs and Pesticides.
7. Up to 10 GW samples will be submitted for VOCs, SVOCs and Metals analyses.
8. Up to 2 GW samples will be submitted for PCBs and Pesticides.
9. Up to 50 soil samples will be submitted for DRO/ORO/GRO
10. Up to 10 soil samples will be submitted for CrVI and/or TEL

**Mining Visualization System (MVS) Model:**

During the creation of the MVS model, calculations will be performed to determine the calculated confidence level of the data and the model. The MVS modeler will use the confidence levels along with a calculated minimum and maximum plume to evaluate the model. As the calculated minimum and maximum plumes converge, the model becomes more acceptable. The required quantity of data to produce an acceptable model will vary with each investigation. The MVS modeler, using professional judgment of the parameters listed above, will determine the acceptability of the model. The modeler will also clearly convey the deficiencies of the model.

**Where, when, and how should the data be collected/generated?**

Soil samples and GW samples will be collected during the weeks of December 1, 2015 through December 15, 2015 from the locations detailed in Worksheet 18. Soil samples will be collected using direct push technology per SERAS SOP#2012, *Soil Sampling*. GW will be collected in accordance with SERAS SOP #2007, *Groundwater Well Sampling*.

Analytical data will be generated by outside laboratories or the CLP laboratory per the Analytical Methods listed in Worksheet 23.

**Who will collect and generate the data?**

CPT/ROST data will be collected and generated by the CPT/ROST subcontractor.

All Field XRF and MultiRAE data will be generated by SERAS Chemists.

All VOC, SVOC, Metals, PCB and pesticide data will be generated by the Region 6 CLP laboratory.

All GRO, ORO, DRO, CrVI and TEL data will be generated by Katahdin Analytical and TestAmerica Buffalo.

SERAS Personnel will also collect Global Positioning System (GPS), geologic core logging data, and elevation data.

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**How will the data be reported?**

The modeled data will be reported on a daily basis as a Ctech 4Dim file. The 4Dim file is a proprietary file format developed by Ctech, Inc. for the visual representation of the MVS models. The model can be manipulated in a 3D environment using Ctech's free 4Dim player. The 4Dim file will be created from "scenes" from the model as chosen by ERT/SERAS and the MVS modeler which can include as necessary or desired:

- CPT data
- Plume Shells of XRF results
- Slices of three-dimensional CPT/ROST data
- Two-dimensional (2D) maximum results for ROST results
- Geologic information from CPT data

Following completion of the field program and finalization of the 3D model, the modeler will provide a data visualization report which will include a description of the MVS visualization methodologies, results, and all QA/QC performed on the model. The actual figures required for each project will vary based on the requirements of the project. These requirements must be communicated with the modeler for inclusion in the final report. Any model deficiencies (data gaps) will be clearly outlined in the final visualization report.

All data collection will be documented in SCRIBE. A final SCRIBE file will be posted to the ERT-IMS website.

All validated VOC, SVOC, Metals, PCB and Pesticide data will be reported directly to the WAM by EPA Region 6 and then forwarded to the SERAS TL. Validated CrVI and TEL data will be reported to the WAM and TL by the SERAS data validation department in a Final Analytical Report. Non-validated ORO, DRO, and GRO data will be reported to the TL by the subcontract laboratory. A final Trip Report, prepared in accordance with SERAS SOP #4017, *Preparation of Trip Reports*, will be the final deliverable to the EPA/ERT WAM. The Trip Report will include all XRF data (tabulated by location), MultiRae VOC data (tabulated by location), and geoprobe core logs. Data will be disseminated to EPA Region 6 by the ERT WAM..

The SERAS TL will be responsible for reviewing, evaluating, summarizing, and presenting all of the data generated from this project. All reports will be posted on the project-specific ERT-Information Management System (IMS) website. Data will be disseminated to Regional EPA Representatives by the WAM.

**How will the data be archived?**

Hard copies of all deliverables will be stored in SERAS Central Files and e-copies will be stored on SERAS Local Area Network (LAN). Analytical results and GPS data will be imported into a Scribe database and posted to the ERT-IMS website. Data will be archived by SERAS in accordance with Administrative Procedure (AP) #34, *Archiving Data Electronic Files*. Subcontract analytical data will be archived by the SERAS QA/QC Group.

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**QAPP Worksheet #12-1**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TCL Volatile Organics				
<b>Concentration Level</b>	Low (ug/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	SOM01.2	Precision (field)	±20% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	20%RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***DMCs; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\***Optional** MS/MSD – Reference CLP SOM01.2, Exhibit D, Table 6 for Criteria

\*\*\*Deuterated Monitoring Compounds (DMCs) – Reference CLP SOM01.2, Exhibit D, Table 5 for Criteria

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### QAPP Worksheet #12-2 Measurement Performance Criteria Table

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TCL Semivolatiles				
<b>Concentration Level</b>	Low (ug/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	SOM02.2	Precision (field)	±20% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	Project-Specific %RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***DMCs; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\***Optional** MS/MSD – Reference CLP SOM02.2, Exhibit D, Table 6 for Criteria

\*\*\*Deuterated Monitoring Compounds (DMCs) – Reference CLP SOM01.2, Exhibit D, Table 5 for Criteria

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**QAPP Worksheet #12-3**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TCL Pesticides				
<b>Concentration Level</b>	Low (ug/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	SOM01.2	Precision (field)	±20% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	20%RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***LCS; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\*MS/MSD – Reference CLP SOM01.2, Exhibit D, Table 3 for Criteria

\*\*\*Laboratory Control Sample (LCS) – Reference CLP SOM01.2, Exhibit D, Table 2 for Criteria

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**QAPP Worksheet #12-4**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TCL Aroclors (PCBs)				
<b>Concentration Level</b>	Low(ug/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	SOM01.2	Precision (field)	±20% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	20% RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***LCS; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\*MS/MSD – Reference CLP SOM01.2, Exhibit D, Table 1 for Criteria

\*\*\*Laboratory Control Sample (LCS) – Reference CLP SOM01.2, Exhibit D, Table 2 for Criteria

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**QAPP Worksheet #12-5**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TAL Metals				
<b>Concentration Level</b>	ICP-AES (ug/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	ISM02.2	Precision (field)	20% RPD*	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	≤20% RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%; 70–130%	*** Matrix Spike; LCS****	A A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-AES for Duplicate Sample Analysis, p. D-22 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-AES for Spike Sample Analysis, p. D-21

\*\*\*\*Reference USEPA CLP ISM012.2 (2014), Exhibit D of ICP-AES for Laboratory Control Sample (LCS), p. D-23 Criteria w/exception of Ag and Sb

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**QAPP Worksheet #12-6**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TAL Metals				
<b>Concentration Level</b>	ICP-MS (ug/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	ISM02.2	Precision (field)	±20% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	±20% RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%; 70–130 %	*** Matrix Spike; LCS****	A A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-MS for Duplicate Sample Analysis, p. D-25 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-MS for Spike Sample Analysis, p. D-24

\*\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-MS for Laboratory Control Sample (LCS), p. D-26

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**QAPP Worksheet #12-7**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TAL –Total Mercury				
<b>Concentration Level</b>	Cold Vapor Atomic Absorption (CVAA)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	ISM02.2	Precision (field)	±20% RPD*	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	±20% RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%	*** Matrix Spike;	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of Mercury for Duplicate Sample Analysis, p. D-19 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of Mercury for Spike Sample Analysis, p. D-18

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**QAPP Worksheet #12-8**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Aqueous				
<b>Analytical Group</b>	TAL –Total Cyanide				
<b>Concentration Level</b>	Colorimeter or Spectrophotometer				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	ISM02.2	Precision (field)	$\pm 20\%$ RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	$\leq 20\%$ RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%	*** Matrix Spike	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of Cyanide for Duplicate Sample Analysis, p. D-20 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of Cyanide for Spike Sample Analysis, p. D-19

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**QAPP Worksheet #12-9**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Water				
<b>Analytical Group<sup>1</sup></b>	Cr(VI)				
<b>Concentration Level</b>	Low				
<b>Sampling Procedure<sup>2</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	Katahdin SOP #CA-772	Accuracy	%R = 80-120 (SM) %R = 85-115% (EPA)	Matrix Spike	S & A
		Accuracy	%R = 90-110	LCS	A
		Accuracy	<RL	Field Blank	S & A
		Precision	±20% RPD	MS/MSD or sample and duplicate	S & A
		Precision (field)	±20% RPD	Field Duplicate	S & A
		Accuracy	< RL	Method Blank	A
		Completeness	>90% sample collection >90% sample analysis	Data Completeness Check	S & A

<sup>1</sup>Reference number from QAPP Worksheet #21 (See Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (See Section 3.2)

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**QAPP Worksheet #12-10**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Water				
<b>Analytical Group<sup>1</sup></b>	Tetraethyl Lead				
<b>Concentration Level</b>	Low				
<b>Sampling Procedure<sup>2</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2007	Test America BF-MB-010	Precision (Field)	RPD: $\pm 20\%$	Field Duplicate	S&A
		Accuracy/Bias	Within control chart limits	MS	S & A
		Precision	Within control chart limits	MS/MSD	S & A
		Accuracy/Bias	Within control chart limits	LCS	A
		Accuracy/Bias	Within control chart limits	Surrogate Spikes	A
		Accuracy/Bias Contamination	<RL	Method Blank	A
		Accuracy/Bias	50-200%	Internal Standards	A
		Accuracy/Bias (Contamination)	<RL	Field Blank	S & A
		Completeness	> 90% sampling completed > 90% laboratory analysis	Data Completeness Check	S & A

<sup>1</sup>Reference number from QAPP Worksheet #21 (See Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (See Section 3.2)

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**QAPP Worksheet #12-11**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TCL Volatiles				
<b>Concentration Level</b>	Low (ug/kg)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	SOM02.2	Precision (field)	±35% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	±35% RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***DMCs; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21

<sup>2</sup>Reference number from QAPP Worksheet #23

\*Based on individual Region's validation criteria

\*\***Optional** MS/MSD – Reference CLP SOM02.2, Exhibit D, Table 6 for Criteria

\*\*\*Deuterated Monitoring Compounds (DMCs) – Reference CLP SOM02.2, Exhibit D, Table 5 for Criteria

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**QAPP Worksheet #12-12**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TCL Semivolatiles				
<b>Concentration Level</b>	Low (ug/kg)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	SOM02.2	Precision (field)	±35% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	±35% RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***DMCs; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\* Based on individual Region's validation criteria

\*\***Optional** MS/MSD – Reference CLP SOM02.2, Exhibit D, Table 6 for Criteria

\*\*\*Deuterated Monitoring Compounds (DMCs) – Reference CLP SOM02.2, Exhibit D, Table 5 for Criteria

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**QAPP Worksheet #12-13**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TCL Pesticides				
<b>Concentration Level</b>	Low (ug/kg)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	SOM01.2	Precision (field)	±35% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	±35% RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***LCS; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\*MS/MSD – Reference CLP SOM01.2, Exhibit D, Table 3 for Criteria

\*\*\*Laboratory Control Sample (LCS) – Reference CLP SOM01.2, Exhibit D, Table 2 for Criteria

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**QAPP Worksheet #12-14**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TCL Aroclors (PCBs)				
<b>Concentration Level</b>	Low (ug/kg)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOPP #2012	SOM01.2	Precision (field)	±35% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	±35% RPD; List compound specific RPD	Field Duplicate; MS/MSD**	S & A; A
		Accuracy (laboratory)	List compound specific %R	***LCS; MS/MSD**	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\*MS/MSD – Reference CLP SOM01.2, Exhibit D, Table 3 for Criteria

\*\*\*Laboratory Control Sample (LCS) – Reference CLP SOM01.2, Exhibit D, Table 2 for Criteria

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**QAPP Worksheet #12-15**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TAL Metals (Salts)				
<b>Concentration Level</b>	ICP-AES (mg/kg)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	ISM02.2	Precision (field)	$\pm 35\%$ RPD*	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	$\leq 20\%$ RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75-125%; 70-130%	*** Matrix Spike; LCS****	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-AES for Duplicate Sample Analysis, p. D-22 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-AES for Spike Sample Analysis, p. D-21

\*\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-AES for Laboratory Control Sample (LCS), p. D-23 Criteria w/exception of Ag and Sb

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**QAPP Worksheet #12-16**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TAL Metals				
<b>Concentration Level</b>	ICP-MS (µg/L)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	ISM02.2	Precision (field)	≤ 35% RPD*	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank*	S & A
		Precision (laboratory)	≤ 20% RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%; 70–130 %	*** Matrix Spike; LCS****	A A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-MS for Duplicate Sample Analysis, p. D-25 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-MS for Spike Sample Analysis, p. D-24

\*\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of ICP-MS for Laboratory Control Sample (LCS), p. D-26

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**QAPP Worksheet #12-17**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TAL –Total Mercury				
<b>Concentration Level</b>	Cold Vapor Atomic Absorption (CVAA)				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	ISM02.2	Precision (field)	$\pm 35\%$ RPD*	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	$\pm 20\%$ RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%	*** Matrix Spike	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on the individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of Mercury for Duplicate Sample Analysis, p. D-19 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of Mercury for Spike Sample Analysis, p. D-18

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**QAPP Worksheet #12-18**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	TAL –Total Cyanide				
<b>Concentration Level</b>	Colorimeter or Spectrophotometer				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	ISM02.2	Precision (field)	≤35% RPD	Field Duplicate	S & A
		Accuracy (field)	No analyte > CRQL*	Field Blank	S & A
		Precision (laboratory)	≤20% RPD*	Duplicate Sample **	A
		Accuracy (laboratory)	75–125%	*** Matrix Spike	A

<sup>1</sup>Reference number from QAPP Worksheet #21.

<sup>2</sup>Reference number from QAPP Worksheet #23.

\*Based on the individual Region's validation criteria

\*\* Reference USEPA CLP ISM02.2 (2014), Exhibit D of Cyanide for Duplicate Sample Analysis, p. D-20 (include absolute difference criteria)

\*\*\*Reference USEPA CLP ISM02.2 (2014), Exhibit D of Cyanide for Spike Sample Analysis, p. D-19

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**QAPP Worksheet #12-19**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	GRO				
<b>Concentration Level</b>	Low				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&amp;A)</b>
SERAS SOP #2012	Katahdin SOP #CA-316	Accuracy/Bias (Contamination)	<Practical Quantitation Limit (PQL)	Method Blank (MB)	A
		Accuracy/Bias	%R = Within laboratory's established control chart limits	Laboratory Control Sample (LCS)/Laboratory Control Sample Duplicate (LCSD)	A
		Accuracy/Bias	%R = Within laboratory's established control chart limits	Matrix Spike (MS)	S&A
		Precision	RPD $\pm$ 50% (MS/MSD) RPD $\pm$ 20% (sample and duplicate)	MS/Matrix Spike Duplicate (MSD) or Sample and duplicate	S&A

<sup>1</sup>Reference number from QAPP Worksheet #21 (see Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (see Section 3.2)

**QAPP Worksheet #12-20**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	DRO/ORO				
<b>Concentration Level</b>	Low to LNAPL				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&amp;A)</b>
SERAS SOP #2012	Katahdin SOP #CA-315	Accuracy/Bias (Contamination)	<Practical Quantitation Limit (PQL)	Method Blank (MB)	A
		Accuracy/Bias	%R = Within laboratory's established control chart limits	Laboratory Control Sample (LCS)	A
		Accuracy/Bias	%R = Within laboratory's established control chart limits	Matrix Spike (MS)	S&A
		Precision	RPD $\pm$ 50% (MS/MSD) RPD $\pm$ 20% (sample and duplicate)	MS/Matrix Spike Duplicate (MSD) or Sample and duplicate	S&A

<sup>1</sup>Reference number from QAPP Worksheet #21 (see Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (see Section 3.2)

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**QAPP Worksheet #12-21**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil
<b>Analytical Group<sup>1</sup></b>	Cr(VI)
<b>Concentration Level</b>	Low

<b>Sampling Procedure<sup>2</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&amp;A)</b>
SERAS SOP #2012	Katahdin SOP #CA-625-06	Accuracy	%R = 80-120%	LCS	A
		Accuracy	±25% of true value	Soluble and Insoluble Pre-Digestion Matrix Spikes	A
		Accuracy	±15% of true value	Post-Digestion Matrix Spike	A
		Precision	RPD ±20%	Duplicate Sample	A
		Precision (field)	±35% RPD	Field Duplicate	S & A
		Accuracy	< RL	Method Blank	A
		Completeness	>90% sample collection >90% sample analysis	Data Completeness Check	S & A

<sup>1</sup>Reference number from QAPP Worksheet #21 (See Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (See Section 3.2)

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**QAPP Worksheet #12-22**  
**Measurement Performance Criteria Table**

Matrix	Soil				
Analytical Group <sup>1</sup>	Tetraethyl Lead				
Concentration Level	Low				
Sampling Procedure <sup>2</sup>	Analytical Method/SOP <sup>2</sup>	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample and/or Activity Used to Assess Measurement Performance	QC Sample Assesses Error for Sampling (S), Analytical (A) or both (S&A)
SERAS SOP #2012	Test America BF-MB-010	Precision (Field)	RPD: ±35%	Field Duplicate	S&A
		Accuracy/Bias	Within control chart limits	MS	S & A
		Precision	Within control chart limits	MS/MSD	S & A
		Accuracy/Bias	Within control chart limits	LCS	A
		Accuracy/Bias	Within control chart limits	Surrogate Spikes	A
		Accuracy/Bias Contamination	<RL	Method Blank	A
		Accuracy/Bias	50-200%	Internal Standards	A
		Completeness	> 90% sampling completed > 90% laboratory analysis	Data Completeness Check	S & A

<sup>1</sup>Reference number from QAPP Worksheet #21 (See Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (See Section 3.2)

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**QAPP Worksheet #12-23**  
**Measurement Performance Criteria Table**

<b>Matrix</b>	Soil				
<b>Analytical Group</b>	Metals (FP XRF) – In-Situ				
<b>Concentration Level</b>	NA				
<b>Sampling Procedure<sup>1</sup></b>	<b>Analytical Method/SOP<sup>2</sup></b>	<b>Data Quality Indicators (DQIs)</b>	<b>Measurement Performance Criteria</b>	<b>QC Sample and/or Activity Used to Assess Measurement Performance</b>	<b>QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&amp;A)</b>
SERAS SOP #2012	SERAS SOP # 1720	Sensitivity	< Reporting Limit (RL)	Zero check sample	A
		Precision	%RSD $\pm$ 20%	Precision check sample	A
		Accuracy/Bias	Element results typically within $\pm$ 20% of true values for concentrations at least 5X the RL	Certified Reference Standard(s)	A
		Completeness	>90% Sampling Completed >90% Laboratory Analysis	Data Completeness Check	S & A

<sup>1</sup>Reference number from QAPP Worksheet #21 (see Section 3.1.2)

<sup>2</sup>Reference number from QAPP Worksheet #23 (see Section 3.2)

**QAPP Worksheet #13**  
**Existing Data Criteria and Limitations Table**

<b>Existing Data</b>	<b>Data Source (Originating Organization, Report Title, and Date)</b>	<b>Data Generator(s) (Originating Org., Data Types, Data Generation/ Collection Dates)</b>	<b>How Data Will Be Used</b>	<b>Limitations on Data Use</b>
Expanded Site Inspection Wilcox Refinery	USEPA Region 6, Expanded Site Inspection Report 1997	Roy F. Weston, Inc. March 1997	Provide insight into the conditions and contamination to be found at the site.	None
Site Assessment	USEPA Region 6. Site Assessment Report for Wilcox Refinery	Ecology and Environment, Inc. Dallas, TX. 1999	Provide insight into the conditions and contamination to be found at the site.	None
Site Inspection Report Lorraine Refinery	Oklahoma Department of Environmental Quality (DEQ), Site Inspection Report- Lorraine Refinery	Oklahoma DEQ	Provide insight into the conditions and contamination to be found at the site.	
Site Conditions and Analysis Plan	Expanded Site Inspection and Analysis Plan	Oklahoma DEQ	Provide insight into the conditions and contamination to be found at the site.	
LIDAR Maps of the refineries.	Oklahoma DEQ	Oklahoma DEQ subcontractor.	Provide insight into the locations, conditions and contamination to be found at the site.	Data is missing Geo-reference information and will be digitally scaled for use with the Trimble GPS.
Historical Aerial Photographic Maps 1956 and 1941	Aerial Oklahoma, Site in Section 20/29-16N-9E Creek County	Aerial Oklahoma	Provide insight into the locations, conditions and contamination to be found at the site.	Data is missing Geo-reference information and will be digitally scaled for the locations of the tanks.
Geophysical Report	SERAS Geophysical Investigation	SERAS	Data will be used to guide the CPT/ROST investigation	None

## **QAPP Worksheet #14**

### **Summary of Project Tasks**

#### **Sampling Tasks:**

1. CPT/ROST sampling will be subcontracted to an outside vendor. CPT/ROST will be performed at a number of locations to be determined by field results and field time constraints. Two rigs will be utilized for a minimum of 10 working days.
2. Direct Push Technology (DPT) sampling will be subcontracted to an outside vendor. DPT will be performed at a number of locations to be determined in the field by CPT/ROST results and field time constraints. One DPT rig will be utilized for a minimum of 10 working days.
3. Field XRF will be used to measure metals content in approximately five locations in each DPT core sample. Special attention will be given to areas that transition greatly between large particles and small particles or other visible layering.
4. Sampling of each core will be based on visual inspection, Field XRF results, and MultiRAE PID screening results. Special attention will be given to “stained” areas or areas for which high PID readings occur. Approximately 100 soil samples will be collected for VOCs, SVOCs, and Metals. Approximately 10 soil samples will be collected for PCBs and Pesticides.
5. Up to 10 temporary wells will be installed using the Geoprobe™. These wells will be sampled and up to 10 samples will be collected for VOCs, SVOCs, and Metals. Up to 2 samples will be collected for PCBs and Pesticides. Additional samples may be collected for CrVI and TEL based on field screening results.

CPT/ROST will be decontaminated on site and investigation-derived waste collected in a 5-gallon bucket which will then be transferred to a Department of Transportation (DOT)-certified steel drum or other approved container.

#### **Analysis Tasks:**

1. All samples will be analyzed per the details in Worksheet 19, Analytical SOP Requirements.
2. Cores will be analyzed by field XRF per SERAS SOP# 1720, *Operation of the Niton XLT 792YW Field Portable X-Ray Fluorescence Unit*.

#### **3-D Modeling Analysis**

- **Review CPT/ROST Data.** All data will be reviewed for completeness prior to uploading into the SCRIBE database.
- **Import data into SCRIBE.** All data will be recorded and stored in the SCRIBE Database using import features generated specifically for import of CPT/XRF data.
- **Export from SCRIBE to MVS .APDV file.** Using a specially designed SCRIBE report, all data will be exported from SCRIBE into an APDV file for import into the MVS Software.
- **Kriging using MVS.** Kriging will be completed using the MVS kriging algorithm. The process of kriging uses a grid of nodes around existing data sets and then, using defined parameters, calculates the values at each node. The grid spacing, kriging data processing parameters, and statistical parameters will be chosen by the MVS modeler based on professional judgment and guidance from the MVS User’s Guide. All parameters selected will be included in the final report.

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**Quality Control Tasks:** SERAS will collect QA/QC samples for the soil sampling in accordance with EPA CLP guidelines or policies and SERAS SOP #2005, *Quality Assurance/Quality Control Samples*. Field QA/QC samples are described on Worksheet #20 and analytical QA/QC samples are listed on Worksheets #12 and 28.

**3-D Model Quality Control Tasks:**

- **Evaluation of XRF pre/post response data.** All XRF pre/post response data will be evaluated by the MVS modeler to determine the variability of XRF response compared to standard test concentrations. Based on this analysis, correction to the XRF detector responses can be completed to account for variations in XRF response over the length of the field program.
- **Evaluation of statistical model data.** The standard statistical data exported during the kriging of the data, including Confidence Values and Min/Max Plume models will be evaluated by the MVS modeler. Low confidence values or significant differences in the Min/Max plumes will be evaluated by the modeler to determine if the model can be used. Deficiencies (data gaps) will be clearly reported in the final report. These deficiencies can be used to generate a listing of locations which need to be evaluated to complete the investigation and model.

**Existing Data:**

Existing data is described in Worksheet 13.

**Data Management Tasks:**

All soil CPT/ROST and borehole sample locations will be identified by a field assigned number. All soil and GW samples will be identified by a unique SCRIBE-assigned sample number. Analytical data will be imported into the Scribe database upon receipt.

All soil CPT/ROST data will be loaded into the SCRIBE database on a daily basis. This data will then be transmitted to an outside contractor for 3-D modeling. The models will be available for review on the following day.

All deliverables will be generated in accordance to the appropriate SERAS SOP and posted to the ERT-IMS website upon completion. Posting to the ERT-IMS site will be considered as completion of the deliverable.

**Documentation and Records:**

All documentation will be recorded in accordance with SERAS SOP #4001, *Logbook Documentation*. Documents and records that may be generated during this project include: WP, QAPP, HASP, Field Logbooks, Site Map, a Technical Memorandum, and Field Change Forms, if necessary.

**Assessment/Audit Tasks:**

A performance audit of field operations is not anticipated for this project. The tasks associated with the QAPP are assessed using peer review and management system review. Peer review enables the TL to identify and correct reporting errors before reports are submitted. Management system reviews establish compliance with prevailing management structure, policies and procedures, and ensures that the required data are obtained.

**Data Review Tasks:**

All data produced under this UFP-QAPP will be evaluated to determine compliance with the stated collection methods, type, and number of samples collected, sample handling, and correct analytical procedures. Data verification will be performed by the SERAS TL/QC Coordinator. All analytical data deliverables for VOCs, SVOCs, Metals, PCBs and Pesticides will be validated by the EPA Region 6 CLP program. All analytical data deliverables for CrVI and TEL (both soils and GW) will be validated per SERAS SOP# 1017, *Data Validation Procedure for Routine Inorganic Analysis*.

All SERAS project deliverables will receive an internal peer review prior to release, per guidelines established in the SERAS AP #22, *Peer Review of SERAS Deliverables*

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### QAPP Worksheet #15-1 Reference Limits and Evaluation Table

**Matrix:** Water

**Analytical Group:** VOC

**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*			Analytical Method – SOM01.2 Trace Quantitation Limits (ug/L)	Analytical Method – SOM01.2 Low Quantitation Limits (ug/L)
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)		
Dichlorodifluoromethane	75-71-8	300	NA	NA	0.5	5
Chloromethane (Methyl Chloride)	74-87-3	190			0.5	5
Vinyl Chloride	75-01-4		0.019	2	0.5	5
Bromomethane	74-83-9	7.5			0.5	5
Chloroethane	75-00-3	21000			0.5	5
Trichlorofluoromethane	75-69-4	1100			0.5	5
1,1-Dichloroethene	75-35-4	280			0.5	5
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1				0.5	5
Acetone (2-Propanone)	67-64-1	14000			5	10
Carbon Disulfide	75-15-0	810			0.5	5
Methyl Acetate	79-20-9	20000			0.5	5
Methylene Chloride	75-09-2		11	5	0.5	5
trans-1,2-Dichloroethene	156-60-5	360		100	0.5	5
Methyl tert-Butyl Ether	1634-04-4		14		0.5	5
1,1-Dichloroethane	75-34-3		2.7		0.5	5
cis-1,2-Dichloroethene	156-59-2	36		70	0.5	5
2-Butanone (Methyl Ethyl Ketone)	78-93-3	56000			5	10
Bromochloromethane	74-97-5	83			0.5	5
Chloroform	67-66-3		0.22		0.5	5
1,1,1-Trichloroethane	71-55-6	800		200	0.5	5
Cyclohexane	110-82-7	13000			0.5	5
Carbon Tetrachloride	56-23-5		0.45	5	0.5	5
Benzene	71-43-2		0.45	5	0.5	5
1,2-Dichloroethane	107-06-2		0.17	5	0.5	5
Trichloroethene	79-01-6		0.49	5	0.5	5
Methylcyclohexane	108-87-2				0.5	5

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1,2-Dichloropropane	78-87-5		0.44	5	0.5	5
Bromodichloromethane	75-27-4		0.13		0.5	5
cis-1,3-Dichloropropene	10061-01-5				0.5	5
4-Methyl-2-Pentanone	108-10-1	1200			5	10
Toluene	108-88-3	1100		1000	0.5	5
trans-1,3-Dichloropropene	10061-02-6				0.5	5
1,1,2-Trichloroethane	79-00-5		0.28	5	0.5	5
Tetrachloroethene	127-18-4	41		5	0.5	5
2-Hexanone	591-78-6	38			5	10
Dibromochloromethane	124-48-1		0.17		0.5	5
1,2-Dibromoethane	106-93-4		0.0075	0.05	0.5	5
Chlorobenzene	108-90-7	78		100	0.5	5
Ethylbenzene	100-41-4		1.5	70	0.5	5
Xylenes (total)	1330-20-7	190			0.5	5
Styrene	100-42-5	1200		100	0.5	5
Bromoform	75-25-2		3.3		0.5	5
Isopropylbenzene	98-82-8	450			0.5	5
1,1,2,2-Tetrachloroethane	79-34-5		0.076		0.5	5
1,3-Dichlorobenzene	541-73-1				0.5	5
1,4-Dichlorobenzene	106-46-7		0.48	75	0.5	5
1,2-Dichlorobenzene	95-50-1	300		600	0.5	5
1,2-Dibromo-3-chloropropane	96-12-8		0.00033	0.2	0.5	5
1,2,4-Trichlorobenzene	120-82-1				0.5	5
1,2,3-Trichlorobenzene	87-61-6	7			0.5	5
1,4-Dioxane	123-91-1					100

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### QAPP Worksheet #15-2 Reference Limits and Evaluation Table

**Matrix:** Water

**Analytical Group:** SVOC

**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*			Analytical Method – SOM02.2 SIM Quantitation Limits (ug/L)	Analytical Method – SOM02.2 Low Quantitation Limits (ug/L)
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)		
1,1'-Biphenyl	92-52-4	0.83				5
1,2,4,5 Tetrachlorobenzene	95-94-3	1.7				5
2,2'-oxybis(1-Chloropropane)	108-60-1		0.36			5
2,3,4,6-Tetrachlorophenol	58-90-2	240				
2,4,5-Trichlorophenol	95-95-4	1200				5
2,4,6-Trichlorophenol	88-06-2		4			5
2,4-Dichlorophenol	120-83-2	46				5
2,4-Dimethylphenol	105-67-9	360				5
2,4-Dinitrophenol	51-28-5	39				10
2,4-Dinitrotoluene	121-14-2		0.24			5
2,6-Dinitrotoluene	606-20-2		0.048			5
2-Chloronaphthalene	91-58-7	750				5
2-Chlorophenol	95-57-8	91				5
2-Methylnaphthalene	91-57-6	36			0.10	
2-Methylphenol	95-48-7	930				5
2-Nitroaniline	88-74-4	190				10
2-Nitrophenol	88-75-5	NP				5
3,3'-Dichlorobenzidine	91-94-1		0.12			5
3-Nitroaniline	99-09-2					10
4,6-Dinitro-2-methylphenol	534-52-1	1.5				10
4-Bromophenyl-phenylether	101-55-3					5
4-Chloro-3-methylphenol	59-50-7	1400				5
4-Chloroaniline	106-47-8		0.36			5
4-Chlorophenyl-phenyl ether	7005-72-3					5
4-Methylphenol	106-44-5	1900				5
4-Nitroaniline	100-01-6		3.8			10
4-Nitrophenol	100-02-7					10
Acenaphthene	83-32-9	530			0.10	5

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Acenaphthylene	208-96-8				0.10	5
Acetophenone	98-86-2	1900				5
Anthracene	120-12-7	1800			0.10	5
Atrazine	1912-24-9		0.3	3		5
Benzaldehyde	100-52-7	1900				5
Benzo(a)anthracene	56-55-3		0.012		0.10	5
Benzo(a)pyrene	50-32-8		0.0034	0.2	0.10	5
Benzo(b)fluoranthene	205-99-2		0.034	0.2	0.10	5
Benzo(g,h,i)perylene	191-24-2		0.34		0.10	5
Benzo(k)fluoranthene	207-08-9		3.7		0.10	5
Bis(2-Chloroethoxy)methane	111-91-1	59				5
Bis-(2-Chloroethyl) ether	111-44-4		0.014			5
bis(2-Ethylhexyl)phthalate	117-81-7					5
Butylbenzylphthalate	85-68-7		16			5
Caprolactam	105-60-2	9900				5
Chrysene	218-01-9		3.4		0.10	5
Dibenzo(a,h)anthracene	53-70-3		0.0034		0.10	5
Dibenzofuran	132-64-9	7.9				5
Diethylphthalate	84-66-2	15000				5
Dimethylphthalate	131-11-3					5
Di-n-butylphthalate	84-74-2	900				5
Di-n-octylphthalate	117-84-0	200				5
Fluoranthene	206-44-0	800			0.10	5
Fluorene	86-73-7	290			0.10	5
Hexachlorobenzene	118-74-1		0.0098	1		5
Hexachlorobutadiene	87-68-3		0.14			5
Hexachlorocyclopentadiene	77-47-4	0.41		50		5
Hexachloroethane	67-72-1		0.33			5
Indeno(1,2,3-cd)pyrene	193-39-5		0.034		0.10	5
Isophorone	78-59-1		78			5
Naphthalene	91-20-3		0.17		0.10	5
Nitrobenzene	98-95-3		0.14			5
N-Nitrosodiphenylamine	86-30-6		12			5
N-Nitroso-di-n-propylamine	621-64-7		0.011			5
Pentachlorophenol	87-86-5		0.04	1	0.20	10
Phenanthrene	85-01-8				0.10	5
Phenol	108-95-2	5800				5
Pyrene	129-00-0	120			0.10	5

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**QAPP Worksheet #15-3**  
**Reference Limits and Evaluation Table**

**Matrix:** Water  
**Analytical Group:** Pesticides  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*			Analytical Method – SOM01.2 Quantitation Limits (µg/L)
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)	
alpha-BHC	319-84-6		0.0071		0.05
beta-BHC	319-85-7		0.025		0.05
delta-BHC	319-86-8				0.05
gamma-BHC (Lindane)	58-89-9		0.041	0.2	0.05
Heptachlor	76-44-8		0.0014	0.4	0.05
Aldrin	309-00-2		0.00092		0.05
Heptachlor epoxide	1024-57-3		0.0014	0.2	0.05
Endosulfan I	959-98-8				0.05
Dieldrin	60-57-1		0.0017		0.1
4,4'-DDE	72-55-9		0.046		0.1
Endrin	72-20-8	2.3			0.1
Endosulfan II	33213-65-9				0.1
4,4'-DDD	72-54-8		0.031		0.1
Endosulfan sulfate	1031-07-8				0.1
4,4'-DDT	50-29-3		0.23		0.1
Methoxychlor	72-43-5			40	0.5
Endrin ketone	53494-70-5				0.1
Endrin aldehyde	7421-93-4				0.1
alpha-Chlordane	5103-71-9				0.05
gamma-Chlordane	5103-74-2				0.05
Toxaphene	8001-35-2		0.015	3	5

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**QAPP Worksheet #15-4**  
**Reference Limits and Evaluation Table**

**Matrix:** Water

**Analytical Group:** PCB

**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*			Analytical Method – SOM01.2 Quantitation Limits (µg/L)
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)	
Aroclor-1016	12674-11-2		0.22		1
Aroclor-1221	11104-28-2		0.0046		1
Aroclor-1232	11141-16-5		0.0046		1
Aroclor-1242	53469-21-9		0.0078		1
Aroclor-1248	12672-29-6		0.0078		1
Aroclor-1254	11097-69-1		0.0078		1
Aroclor-1260	11096-82-5		0.0078		1
Aroclor-1262	37324-23-5				1
Aroclor-1268	11100-14-4				1

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### QAPP Worksheet #15-5 Reference Limits and Evaluation Table

**Matrix:** Water

**Analytical Group:** TAL Metals (ICP-AES & ICP-MS)

**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*			Analytical Method – ISM02.2 ICP-MS Quantitation Limits (ug/L)	Analytical Method – ISM02.2 ICP-AES Quantitation Limits (ug/L)
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)		
Aluminum	7429-90-5	20000			20	200
Antimony	7440-36-0	7.8			2	60
Arsenic	7440-38-2	0.05	0.05		1	10
Barium	7440-39-3	3800			10	200
Beryllium	7440-41-7	25			1	5
Cadmium	7440-43-9	9.2			1	5
Calcium	7440-70-2				500	5000
Chromium	7440-47-3	22000			2	10
Cobalt	7440-48-4	6			1	50
Copper	7440-50-8	800			2	25
Iron	7439-89-6	14000			200	100
Lead	7439-92-1	15			1	10
Magnesium	7439-95-4				500	5000
Manganese	7439-96-5	430			1	15
Nickel	7440-02-0	390			1	40
Potassium	2023695				500	5000
Selenium	7782-49-2	100			5	35
Silver	7440-22-4	94			1	10
Sodium	7440-23-5				500	5000
Thallium	7440-28-0	0.2			1	25
Vanadium	7440-62-2	86			5	50
Zinc	7440-66-6	6000			2	60

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**QAPP Worksheet #15-6-  
Reference Limits and Evaluation Table**

**Matrix:** Water

**Analytical Group:** Target Analyte List  
Inorganics (Mercury and  
Cyanide)

**Concentration Level:** Low – Mercury and Cyanide

Analyte	CAS Number	Project Action Limits*			Analytical Method – ISM02.2 Cyanide and Mercury Quantitation Limits (µg/L)
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)	
Cyanide	57-12-5	1.5			10
Mercury	7439-97-6	0.63		0.002	0.2

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**QAPP Worksheet #15-7**  
**Reference Limits and Evaluation Table**

**Matrix:** Water

**Analytical Group:** GRO/DRO/ORO

**Concentration Level:** Low

Analyte	CAS Number	Project Action Limit (µg/L)	Project Quantitation Limit (µg/L)	Analytical Method (Katahdin SOP #CA-315 & CA-316)		Achievable Laboratory Limits	
				MDLs (µg/L)	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
GRO (C	NA	NA	10	NS	NS	6.5	10
DRO (C10-C28)	NA	NA	50	NS	NS	9.5	50
ORO (C28-C36)	NA	NA	25	NS	NS	8.4	25

NA = Not Applicable  
NS = Not Specified

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**QAPP Worksheet #15-8**  
**Reference Limits and Evaluation Table**

Matrix: Water

Analytical Group: Cr (VI)

Concentration Level: Low

Analyte	CAS Number	Project Action Limit			Analytical Method		Achievable Laboratory Limits	
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)	MDLs (µg/L)	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
Cr(VI)	7740-47-3	0.035	0.035		NS	NS	0.00171	0.025

NS = Not Specified

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**QAPP Worksheet #15-9**  
**Reference Limits and Evaluation Table**

Matrix: Water

Analytical Group: Tetraethyl Lead

Concentration Level: Low

Analyte	CAS Number	Project Action Limit			Analytical Method		Achievable Laboratory Limits	
		Residential Water (µg/L) HI = 1	Residential Water (µg/L) 1.00E-06	Maximum Contaminant Level (MCL) (µg/L)	MDLs (µg/L)	Method QLs (µg/L)	MDLs (µg/L)	QLs (µg/L)
TEL	78-00-2	0.0013			NS	NS	Lab-specific	10

NS = Not Specified

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### QAPP Worksheet #15-10 Reference Limits and Evaluation Table

**Matrix:** Soil  
**Analytical Group:** VOC  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*		Analytical Method – SOM02.2 Medium Quantitation Limits (µg/kg)	Analytical Method – SOM02.2 Low Quantitation Limits (µg/kg)
		Residential Soil (µg/kg) HI = 1	Residential Soil (µg/kg) 1.00E-06		
Dichlorodifluoromethane	75-71-8	87		250	5
Chloromethane (Methyl Chloride)	74-87-3	110		250	5
Vinyl Chloride	75-01-4		0.59	250	5
Bromomethane	74-83-9	6.8		250	5
Chloroethane	75-00-3	14000		250	5
Trichlorofluoromethane	75-69-4	730		250	5
1,1-Dichloroethene	75-35-4	230		250	5
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1			250	5
Acetone (2-Propanone)	67-64-1	61000		250	10
Carbon Disulfide	75-15-0	770		250	5
Methyl Acetate	79-20-9	78000		250	5
Methylene Chloride	75-09-2		57	250	5
trans-1,2-Dichloroethene	156-60-5	1600		250	5
Methyl tert-Butyl Ether	1634-04-4		47	250	5
1,1-Dichloroethane	75-34-3		3.6	250	5
cis-1,2-Dichloroethene	156-59-2	160		250	5
2-Butanone (Methyl Ethyl Ketone)	78-93-3	27000		250	10
Bromochloromethane	74-97-5	150		250	5
Chloroform	67-66-3		0.32	250	5
1,1,1-Trichloroethane	71-55-6	8100		250	5
Cyclohexane	110-82-7	6500		250	5
Carbon Tetrachloride	56-23-5		0.65	250	5
Benzene	71-43-2		1.2	250	5
1,2-Dichloroethane	107-06-2		0.46	250	5
Trichloroethene	79-01-6		0.94	250	5

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Methylcyclohexane	108-87-2	NP		250	5
1,2-Dichloropropane	78-87-5		1	250	5
Bromodichloromethane	75-27-4		0.29	250	5
cis-1,3-Dichloropropene	10061-01-5	NP		250	5
4-Methyl-2-Pentanone	108-10-1	5300		250	10
Toluene	108-88-3	4900		250	5
trans-1,3-Dichloropropene	10061-02-6	NP		250	5
1,1,2-Trichloroethane	79-00-5		1.1	250	5
Tetrachloroethene	127-18-4		24	250	5
2-Hexanone	591-78-6	200		250	10
Dibromochloromethane	124-48-1		0.75	250	5
1,2-Dibromoethane	106-93-4		0.036	250	5
Chlorobenzene	108-90-7	280		250	5
Ethylbenzene	100-41-4		5.8	250	5
Xylenes (total)	1330-20-7	650		250	5
Styrene	100-42-5	6000		250	5
Bromoform	75-25-2		19	250	5
Isopropylbenzene	98-82-8	1900		250	5
1,1,2,2-Tetrachloroethane	79-34-5		0.6	250	5
1,3-Dichlorobenzene	541-73-1	NP		250	5
1,4-Dichlorobenzene	106-46-7		2.6	250	5
1,2-Dichlorobenzene	95-50-1	1800		250	5
1,2-Dibromo-3-chloropropane	96-12-8		0.00053	250	5
1,2,4-Trichlorobenzene	120-82-1		24000	250	5
1,2,3-Trichlorobenzene	87-61-6	63		250	5
1,4-Dioxane	123-91-1		5300	5000	100

NP = Not Published

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### QAPP Worksheet #15-11 Reference Limits and Evaluation Table

**Matrix:** Soil  
**Analytical Group:** SVOC  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*		Analytical Method – SOM02.2 Medium Quantitation Limits (mg/kg)	Analytical Method – SOM02.2 Low Quantitation Limits (mg/kg)
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06		
1,1'-Biphenyl	92-52-4	47		5	0.17
1,2,4,5 Tetrachlorobenzene	95-94-3	23		5	0.17
2,2'-oxybis(1-Chloropropane)	108-60-1		4.9	5	0.17
2,3,4,6-Tetrachlorophenol	58-90-2	1900			0.17
2,4,5-Trichlorophenol	95-95-4	6300		5	0.17
2,4,6-Trichlorophenol	88-06-2		49	5	0.17
2,4-Dichlorophenol	120-83-2	190		5	0.17
2,4-Dimethylphenol	105-67-9	1300		5	0.17
2,4-Dinitrophenol	51-28-5	130		10	0.33
2,4-Dinitrotoluene	121-14-2		1.7	5	0.17
2,6-Dinitrotoluene	606-20-2		0.36	5	0.17
2-Chloronaphthalene	91-58-7	4800		5	0.17
2-Chlorophenol	95-57-8	390		5	0.17
2-Methylnaphthalene	91-57-6	240			0.17
2-Methylphenol	95-48-7	3200		5	0.17
2-Nitroaniline	88-74-4	630		10	0.33
2-Nitrophenol	88-75-5	NP		5	0.17
3,3'-Dichlorobenzidine	91-94-1		1.2	5	0.17
3-Nitroaniline	99-09-2	NP		10	0.17
4,6-Dinitro-2-methylphenol	534-52-1	5.1		10	0.33
4-Bromophenyl-phenylether	101-55-3	NP		5	0.33
4-Chloro-3-methylphenol	59-50-7	6300		5	0.17
4-Chloroaniline	106-47-8		2.7	5	0.17
4-Chlorophenyl-phenyl ether	7005-72-3	NP		5	0.17
4-Methylphenol	106-44-5	1900		5	0.17
4-Nitroaniline	100-01-6		3.8	10	0.33

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4-Nitrophenol	100-02-7			10	0.33
Acenaphthene	83-32-9	3600		5	0.17
Acenaphthylene	208-96-8	NP		5	0.17
Acetophenone	98-86-2	1900		5	0.17
Anthracene	120-12-7	18000		5	0.17
Atrazine	1912-24-9		0.3	5	0.17
Benzaldehyde	100-52-7	1900		5	0.17
Benzo(a)anthracene	56-55-3		0.012	5	0.17
Benzo(a)pyrene	50-32-8		0.0034	5	0.17
Benzo(b)fluoranthene	205-99-2		0.034	5	0.17
Benzo(g,h,i)perylene	191-24-2	NP	0.34	5	0.17
Benzo(k)fluoranthene	207-08-9		3.7	5	0.17
Bis(2-Chloroethoxy)methane	111-91-1	59		5	0.17
Bis-(2-Chloroethyl) ether	111-44-4		0.014	5	0.17
bis(2-Ethylhexyl)phthalate	117-81-7			5	0.17
Butylbenzylphthalate	85-68-7		16	5	0.17
Caprolactam	105-60-2	9900		5	0.17
Chrysene	218-01-9	15		5	0.17
Dibenzo(a,h)anthracene	53-70-3			5	0.17
Dibenzofuran	132-64-9	73		5	0.17
Diethylphthalate	84-66-2	51000		5	0.17
Dimethylphthalate	131-11-3	NP		5	0.17
Di-n-butylphthalate	84-74-2	6300		5	0.17
Di-n-octylphthalate	117-84-0	630		5	0.17
Fluoranthene	206-44-0	2400		5	0.17
Fluorene	86-73-7	2400		5	0.17
Hexachlorobenzene	118-74-1		0.21	5	0.17
Hexachlorobutadiene	87-68-3		1.2	5	0.17
Hexachlorocyclopentadiene	77-47-4	1.8		5	0.17
Hexachloroethane	67-72-1		1.8	5	0.17
Indeno(1,2,3-cd)pyrene	193-39-5			5	0.17
Isophorone	78-59-1		570	5	0.17
Naphthalene	91-20-3	130		5	0.17
Nitrobenzene	98-95-3		5.1	5	0.17
N-Nitrosodiphenylamine	86-30-6		110	5	0.17
N-Nitroso-di-n-propylamine	621-64-7		0.078	5	0.17
Pentachlorophenol	87-86-5	250	1	10	0.33
Phenanthrene	85-01-8	NP		5	0.17
Phenol	108-95-2	19000		5	0.17

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Pyrene	129-00-0	1800		5	0.17
1,4-Dioxane	123-91-1		5.3	2	0.067

NP = Not Published

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### QAPP Worksheet #15-12 Reference Limits and Evaluation Table

**Matrix:** Soil  
**Analytical Group:** Pesticides  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*		Analytical Method – SOM01.2 Quantitation Limits (mg/kg)
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06	
alpha-BHC	319-84-6		0.086	0.0017
beta-BHC	319-85-7			0.0017
delta-BHC	319-86-8	NP		0.0017
gamma-BHC (Lindane)	58-89-9			0.0017
Heptachlor	76-44-8			0.0017
Aldrin	309-00-2		0.039	0.0017
Heptachlor epoxide	1024-57-3			0.0017
Endosulfan I	959-98-8	NP		0.0017
Dieldrin	60-57-1		0.034	0.0033
4,4'-DDE	72-55-9		2	0.0033
Endrin	72-20-8	19		0.0033
Endosulfan II	33213-65-9	NP		0.0033
4,4'-DDD	72-54-8		2.3	0.0033
Endosulfan sulfate	1031-07-8	NP		0.0033
4,4'-DDT	50-29-3		1.9	0.0033
Methoxychlor	72-43-5	320		0.017
Endrin ketone	53494-70-5	NP		0.0033
Endrin aldehyde	7421-93-4	NP		0.0033
alpha-Chlordane	5103-71-9	NP		0.0017
gamma-Chlordane	5103-74-2	NP		0.0017
Toxaphene	8001-35-2			0.17

NP = Not Published

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**QAPP Worksheet #15-13**  
**Reference Limits and Evaluation Table**

**Matrix:** Soil  
**Analytical Group:** PCB  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*		Analytical Method – SOM01.2 Quantitation Limits (mg/kg)
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06	
Aroclor-1016	12674-11-2	4.1		0.033
Aroclor-1221	11104-28-2		0.17	0.033
Aroclor-1232	11141-16-5		0.17	0.033
Aroclor-1242	53469-21-9		0.23	0.033
Aroclor-1248	12672-29-6		0.23	0.033
Aroclor-1254	11097-69-1		0.24	0.033
Aroclor-1260	11096-82-5		0.24	0.033
Aroclor-1262	37324-23-5	NP		0.033
Aroclor-1268	11100-14-4	NP		0.033

NP = Not Published

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### QAPP Worksheet #15-14 Reference Limits and Evaluation Table

**Matrix:** Soil  
**Analytical Group:** TAL Metals (ICP-AES and ICP-MS)  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*		Analytical Method – ICP-AES -ISM02.2 Quantitation Limits (mg/kg)	Analytical Method –ICP-MS- ISM02.2 Quantitation Limits (mg/kg)
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06		
Aluminum	7429-90-5	77000		20	
Antimony	7440-36-0	31		6	1
Arsenic	7440-38-2	0.67	0.67	1	0.5
Barium	7440-39-3	15000		20	5
Beryllium	7440-41-7	150		0.5	0.5
Cadmium	7440-43-9	70		0.5	0.5
Calcium	7440-70-2	NP		500	
Chromium	7440-47-3	120000		1	1
Cobalt	7440-48-4	23		5	0.5
Copper	7440-50-8	3100		2.5	1
Iron	7439-89-6	55000		10	
Lead	7439-92-1	400		1	0.5
Magnesium	7439-95-4	NP		500	
Manganese	7439-96-5	1800		1.5	0.5
Nickel	7440-02-0	1500		4	0.5
Potassium	7440-09-7	NP		500	
Selenium	7782-49-2	390		3.5	2.5
Silver	7440-22-4	390		1	0.5
Sodium	7440-23-5	NP		500	
Thallium	7440-28-0	0.78		2.5	0.5
Vanadium	7440-62-2	390		5	2.5
Zinc	7440-66-6	23000		6	1

NP = Not Published

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**QAPP Worksheet #15-15**  
**Reference Limits and Evaluation Table**

**Matrix:** Soil, Sediment  
**Analytical Group:** TAL Inorganics (Mercury and Cyanide)  
**Concentration Level:** Low

Analyte	CAS Number	Project Action Limits*		Analytical Method – ISM02.2 Quantitation Limits (mg/kg)
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06	
Cyanide	57-12-5	2.7		0.5
Mercury	7439-97-6	9.4		0.1

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**QAPP Worksheet #15-16**  
**Reference Limits and Evaluation Table**

**Matrix:** Soil

**Analytical Group:** GRO/DRO/ORO

**Concentration Level:** Low

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Quantitation Limit (mg/kg)	Analytical Method (Katahdin SOP #CA-315 & CA-316)		Achievable Laboratory Limits	
				MDLs (mg/kg)	Method QLs (mg/kg)	MDLs (mg/kg)	QLs (mg/kg)
GRO	NA	NA	2.5	NS	NS	1.8	2.5
DRO (C10-C28)	NA	NA	5.0	NS	NS	2.2	5.0
ORO (C28-C36)	NA	NA	2.5	NS	NS	0.6	2.5

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**QAPP Worksheet #15-17**  
**Reference Limits and Evaluation Table**

Matrix: Soil

Analytical Group: Cr (VI)

Concentration Level: Low

Analyte	CAS Number	Project Action Limit* (mg/kg)		Analytical Method		Achievable Laboratory Limits	
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06	MDLs (mg/kg)	Method QLs (mg/kg)	MDLs (mg/kg)	QLs (mg/kg)
Cr(VI)	7740-47-3	0.3	0.3	NS	NS	0.15	0.50

NS = Not Specified

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**QAPP Worksheet #15-18**  
**Reference Limits and Evaluation Table**

Matrix: Soil

Analytical Group: TEL

Concentration Level: Low

Analyte	CAS Number	Project Action Limit* (mg/kg)		Analytical Method		Achievable Laboratory Limits	
		Residential Soil (mg/kg) HI = 1	Residential Soil (mg/kg) 1.00E-06	MDLs (mg/kg)	Method QLs (mg/kg)	MDLs (mg/kg)	QLs (mg/kg)
TEL	78-00-2	0.0078		NS	NS	Lab-specific	0.17

NS = Not Specified

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### QAPP Worksheet #15-19 Reference Limits and Evaluation Table

Matrix: Soil (FPXRF Metals)

Analytical Group: Metals

Concentration Level: Low to high

Analyte	CAS Number	Project Action Limit (mg/kg)	Project Quantitation Limit (mg/kg)	Analytical Method		Achievable Laboratory Limits (mg/kg) <sup>a</sup>	
				MDLs	Method QLs (mg/kg)	MDLs	QLs
Antimony	7440-36-0	TBD	TBD	NS	NS	71	TBD
Arsenic	7440-38-2	TBD	TBD	NS	NS	10	TBD
Cadmium	7440-43-9	TBD	TBD	NS	NS	26	TBD
Calcium	7440-70-2	TBD	TBD	NS	NS	160	TBD
Chromium	7440-47-3	TBD	TBD	NS	NS	42	TBD
Cobalt	7440-48-4	TBD	TBD	NS	NS	230	TBD
Copper	7440-50-8	TBD	TBD	NS	NS	28	TBD
Iron	7439-89-6	TBD	TBD	NS	NS	62	TBD
Lead	7439-92-1	TBD	TBD	NS	NS	13	TBD
Manganese	7439-96-5	TBD	TBD	NS	NS	150	TBD
Mercury	7439-97-6	TBD	TBD	NS	NS	6	TBD
Nickel	7440-02-0	TBD	TBD	NS	NS	67	TBD
Potassium	7440-09-7	TBD	TBD	NS	NS	270	TBD
Selenium	7782-49-2	TBD	TBD	NS	NS	4	TBD
Silver	7440-22-4	TBD	TBD	NS	NS	28	TBD
Strontium	7440-24-6	TBD	TBD	NS	NS	18	TBD
Tin	7440-31-5	TBD	TBD	NS	NS	57	TBD
Vanadium	7440-62-2	TBD	TBD	NS	NS	20	TBD
Zinc	7440-66-6	TBD	TBD	NS	NS	25	TBD

<sup>a</sup> Achievable Laboratory Limits (MDLs) based on 120 second measurements of NIST reference standards and/or SiO<sub>2</sub> blank sample  
TBD – to be determined; project specific limits will be determined per ER by the Task Leader.

NA – not applicable

NS – not specified

mg/kg – milligrams per kilogram

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**QAPP Worksheet #16**  
**Project Schedule Timeline Table**

Activities	Organization	Dates (MM/DD/YY)		Deliverable	Deliverable Due Date
		Anticipated Date(s) of Initiation	Anticipated Date of Completion		
WP preparation	SERAS	08-1-2015	08-19-2015	Yes	
QAPP Revision 1	SERAS	10-01-2015	11-20-2015	Yes	Prior to field activities
HASP Revision 1	SERAS	10-19-2015	11-27-2015	Yes	Prior to field activities
Field Operations	SERAS	12-1-2015	12-16-2015	Yes (Technical Memorandum)	20 Business Days after completion of field activities
3-D Model Generation	S2C2	12-2-2015	Daily	Yes	Day following data generation.
Analytical Results	CLP Laboratories or SERAS Subcontract Laboratories	12-15-2015	1-16-2016	Yes (Analytical Report for subcontract)	20 Business Days for receipt of CLP data 15 Business Days after receipt of analytical data package (subcontract data)

### **QAPP Worksheet #17 Sampling Design and Rationale**

**Describe and provide a rationale for choosing the sampling approach (e.g., grid system, biased statistical approach):**

The CPT/ROST investigation will be done on a biased approach. Based on Geophysical data and bedrock contours, areas will be chosen for the possibility of locating petroleum hydrocarbon byproducts by geophysical results or by deeper areas which could be preferential pathways as well as the original location of the refinery equipment and piping. The WAM and TL will decide the sampling areas on a daily basis. Based on the results of the initial CPT/ROST investigations, additional CPT/ROST points and DPT borings may be added in a grid type approach to better isolate contaminated areas.

DPT sampling will be completed by following the CPT/ROST investigation. Points of interest may be chosen to replicate the CPT/ROST results by sampling to verify and/or identify the compounds found by the CPT/ROST. These points of interest will be determined by unique data that includes but is not limited to:

1. Drastic changes in lithology. Prior investigations as other sites have pointed to changes in lithology, primarily from a larger particle to a clay type material as being areas where contamination can “pool” and/or where the flow pathway can be impacted.
2. Significant ROST results.

Field XRF screening for will be done at approximately five locations within each core sample. These will be selected on a biased professional judgement by the field Geologist, but also visual observation of staining, drastic changes in lithology, or other visual indication of contamination. PID screening of each core will also be used to pinpoint areas of interest within each core.

DPT will also be used to collect discrete data points regarding the depth to bedrock. No samples will be collected, only data points for these locations.

Samples for GRO/DRO/ORO, VOCs, SVOCs, Metals, PCB/Pesticides, will be chosen from each core in the same biased method as the field XRF screening areas are chosen. The location and depth of each sample will be recorded in the SCRIBE database.

GW wells will be installed and sampled in a biased manner based on either CPT/ROST or Field XRF/PID Screening indicating elevated levels of contaminants which could be impacting GW. Should screening not indicate possible impacted GW, wells may still be installed to collect general GW samples.

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**Describe the sampling design and rationale in terms of what matrices will be sampled, what analytical groups will be analyzed and at what concentration levels, the sampling locations (including QC, critical, and background samples), the number of samples to be taken, and the sampling frequency (including seasonal considerations) [May refer to map or Worksheet #18 for details]:**

Contamination at the site is considered to be mainly residual petroleum hydrocarbons or fuel additives remaining in soils. To that end, soils will be the primary matrix of interest. CPT/ROST and DPT will be used to investigate soils in the three areas of interest, the Refinery areas, the Tank Farm area, and the Creeks and Boundaries areas. The CPT/ROST and DPT investigations will be completed in a continuous manner for a period of a minimum of two weeks. At the completion of the two week sample period, the data will be evaluated and a decision regarding additional sampling will be made. The total number of CPT/ROST and DPT locations will be based on depths and areas and cannot be defined at this time.

DPT sample cores will be taken in a continuous manner every five feet until refusal is encountered. Refusal is expected to be between 0 and 25 feet below ground surface (bgs).

A total of up to 100 soil samples will be taken from DPT cores for VOCs, SVOCs and Metals Analyses.

A total of up to 10 soil samples will be submitted for PCBs and Pesticides.

A total of up to 50 soil samples will be submitted for DRO/ORO/GRO.

A total of up to 10 soil samples will be submitted for CrVI and/or TEL.

GW is of secondary concern as some contamination has migrated off-site and is believed to have been carried by either GW and/or surface water. To that end, up to ten temporary wells will be installed in areas of interest as determined in the field and the following samples will be collected:

Up to 10 GW samples will be submitted for VOCs, SVOCs, CrVI, TEL and Metals.

Up to 2 GW samples will be submitted for PCBs and Pesticides.

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**QAPP Worksheet #18**  
**Sampling Locations and Methods/SOP Requirements Table**

<b>Sampling Location/ID Number</b>	<b>Matrix</b>	<b>Depth</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Number of Samples</b>	<b>Sampling SOP Reference</b>	<b>Rationale for Sampling Location</b>
Tank Farm Area TF-CPT-001 through TF-CPT-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	CPT/ROST	High	Continuous	Fugro Field Operations Procedure	Biased Professional Judgement
Tank Farm Area TF-SB-001 through TF-SB-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	Field XRF	High	Approximately five XRF Readings will be collected from every 5-ft core	SERAS SOP#2012 and SERAS SOP#1720	Biased based on CPT/ROST Results
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	VOCs, SVOCs, Metals	High	Approximately 40. Total between all areas not to exceed 100	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	PCBs, Pesticides, CrVI, TEL	High	Approximately 4. Total between all areas not to exceed 10	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	DRO/ORO/ GRO	High	Approximately 20. Total between all areas not to exceed 50	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
Wilcox Refinery Area WR-CPT-001 through WR-CPT-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	CPT/ROST	High	Continuous	Fugro Field Operations Procedure	Biased Professional Judgement

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Sampling Location/ID Number	Matrix	Depth	Analytical Group	Concentration Level	Number of Samples	Sampling SOP Reference	Rationale for Sampling Location
Wilcox Refinery Area WR-SB-001 through WR-SB-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	Field XRF	High	Approximately five XRF Readings will be collected from every 5-ft core	SERAS SOP#2012 and SERAS SOP#1720	Biased based on CPT/ROST Results
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	VOCs, SVOCs, Metals	High	Approximately 20. Total between all areas not to exceed 100	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	PCBs, Pesticides, CrVI, TEL	High	Approximately 2. Total between all areas not to exceed 10	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	DRO/ORO/GRO	High	Approximately 10. Total between all areas not to exceed 50	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
Lorraine Refinery Area LR-CPT-001 through LR-CPT-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	CPT/ROST	High	Continuous	Fugro Field Operations Procedure	Biased Professional Judgement
Lorraine Refinery Area LR-SB-001 through LR-SB-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	Field XRF	High	Approximately five XRF Readings will be collected from every 5-ft core	SERAS SOP#2012 and SERAS SOP#1720	Biased based on CPT/ROST Results
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	VOCs, SVOCs, Metals	High	Approximately 20. Total between all areas not to exceed 100	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	PCBs, Pesticides, CrVI, TEL	High	Approximately 2. Total between all areas not to exceed 10	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement

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Sampling Location/ID Number	Matrix	Depth	Analytical Group	Concentration Level	Number of Samples	Sampling SOP Reference	Rationale for Sampling Location
Lorraine Refinery Area LR-SB-001 through LR-SB-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	DRO/ORO/GRO	High	Approximately 10. Total between all areas not to exceed 50	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
Boundary Areas BA-CPT-001 through BA-CPT-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	CPT/ROST	High	Continuous	Fugro SOP	Biased Professional Judgement
Boundary Areas BA-SB-001 through BA-SB-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	Field XRF	High	Approximately five XRF Readings will be collected from every 5-ft core	SERAS SOP#2012 and SERAS SOP#1720	Biased based on CPT/ROST Results
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	VOCs, SVOCs, Metals	High	Approximately 20. Total between all areas not to exceed 100	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	PCBs, Pesticides, CrVI, TEL	High	Approximately 2. Total between all areas not to exceed 10	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	DRO/ORO/GRO	High	Approximately 10. Total between all areas not to exceed 50	SERAS SOP#2012	Biased based on CPT/ROST Results and Professional Geologist Judgement
Boundary Areas BA-SB-001 Through BA-SB-XXX	Soil	0 to Refusal (assumed to be between 0 and 20 ft bgs.	Field XRF	High	Approximately five XRF Readings will be collected from every 5-ft core	SERAS SOP#2012 and SERAS SOP#1720	Biased based on CPT/ROST Results
GW Wells XX-GW-01 through XX-GW-10 XX to be either TF, WR, LR or BA	GW	Screened depth to be a 4-ft screen ending at refusal depth	VOCs, SVOCs, GRO/DRO/ORO, CrVI, TEL and Metals	High	Up to 10	SERAS SOP#2007	Biased based on CPT/ROST Results and Geophysical Results

**QAPP Worksheet #19**  
**Analytical SOP Requirements Table**

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
Soil	VOC	Low	SOM02.2/5035	5 grams(g)	(3) Encore Samplers plus (1) 2-oz Jar	Iced to <6 °C	48 Hours
	SVOC	Low	SOM02.2	150g	(1) 8-ounce (oz) Jar	Iced to <6 °C	Extraction within 14 days of collection; analysis within 40 days of extraction
	PCB	Low	SOM01.2	150g	(1) 8-ounce (oz) Jar	Iced to <6 °C	Extraction within 14 days of collection; analysis within 40 days of extraction
	Pesticides	Low	SOM01.2	150g	(1) 8-ounce (oz) Jar	Iced to <6 °C	Extraction within 14 days of collection; analysis within 40 days of extraction
	Metals	Low	ISM02.2/ICP-MS with salts (ICP-AES)	Full Jar	(1) 8-ounce (oz) Jar	Iced to <6 °C	6 months for ICP metals
	Mercury	Low	ISM02.2/CVAA	Full Jar	(1) 8-ounce (oz) Jar	Iced to <6 °C	28 days for mercury
	Cyanide	Low	ISM02.2/ Colorimetric	Full Jar	(1) 8-ounce (oz) Jar	Iced to <6 °C	14 days for cyanide
	GRO/DRO/ORO	Low	Katahdin SOP #CA-316 Katahdin SOP #CA-315	GRO - 10 g DRO/ORO – 30 g	GRO - 40-mL septum vials DRO/ORO – 4-oz jar	Iced to <6 °C	GRO – Within 14 days of collection DRO/ORO – Extraction within 14 days of collection; analysis within 40 days of extraction

**QAPP Worksheet #19**  
**Analytical SOP Requirements Table**

Matrix	Analytical Group	Concentration Level	Analytical and Preparation Method/SOP Reference	Sample Volume	Containers (number, size, and type)	Preservation Requirements (chemical, temperature, light protected)	Maximum Holding Time (preparation/ analysis)
	CrVI	Low	Katahdin SOP #CA-625	5g	4-oz jar	Iced to <6 °C	Within 30 days of collection Within 24 hours after extraction
	TEL	Low	TestAmerica – Buffalo SOP #BF-MB-010	30 g	(1) 8-ounce (oz) Jar	Iced to <6 °C	Extraction within 14 days of collection; analysis within 40 days of extraction
GW	VOC	Low	SOM01.2 (SIM)	160 mL	(4) 40 mL VOA Vials	Iced to <6 °C	7 days
	SVOC	Low	SOM02.2 (SIM added)	2 Liters(L)	(2)Amber Round 1-L Glass Bottles	Iced to <6 °C	Extraction within 7 days of collection; analysis within 40 days of extraction
	PCB	Low	SOM01.2	2L	(2)Amber Round 1-L Glass Bottles	Iced to <6 °C	Extraction within 7 days of collection; analysis within 40 days of extraction
	Pesticides	Low	SOM01.2	2L	(2)Amber Round 1-L Glass Bottles	Iced to <6 °C	Extraction within 7 days of collection; analysis within 40 days of extraction
	Metals	Low	ISM02.2/ICP-MS	1L	(1) Poly 1-L Bottle	pH < 2 with HNO <sub>3</sub> , Iced to <6 °C	6 Months except Hg (28 days)
	Mercury	Low	ISM02.2/CVAA	1L	(1) Poly 1-L Bottle	pH < 2 with HNO <sub>3</sub> , Iced to <6 °C	28 days for mercury

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**QAPP Worksheet #19**  
**Analytical SOP Requirements Table**

<b>Matrix</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Analytical and Preparation Method/SOP Reference</b>	<b>Sample Volume</b>	<b>Containers (number, size, and type)</b>	<b>Preservation Requirements (chemical, temperature, light protected)</b>	<b>Maximum Holding Time (preparation/analysis)</b>
	Cyanide	Low	ISM02.2/ Colorimetric	1L	(1) Poly 1-L Bottle	pH>10 with NaOH; Iced to <6 °C	14 days for cyanide
	CrVI	Low	Katahdin SOP #CA- 772	1L	(1) Poly 1-L Bottle	Iced to <6 °C	Within 24 hours
	TEL	Low	TestAmerica – Buffalo SOP #BF- MB-010	2 Liters(L)	(2)Amber Round 1-L Glass Bottles	Iced to <6 °C	7 Days

**QAPP Worksheet #20**  
**Field Quality Control Sample Summary Table**

Matrix	Analytical Group	Concentration Level	Analytical and Preparation SOP Reference	No. of Sampling Locations	No. of Field Duplicate Pairs	Inorganic No. of MS	No. of Trip Blanks	No. of Equip. Blanks	No. of PT Samples	Total No. of Samples to Lab
Soil	VOC	Low	SOM02.2	100	10	0	1 per trip (est. 5)	0	0	115
	SVOC	Low	SOM02.2	100	10	0	0	0	0	110
	PCB	Low	SOM01.2	10	1	1	0	0	0	12
	Pesticides	Low	SOM01.2	10	1	1	0	0	0	12
	Metals	Low	ISM02.2/ICP-MS with salts (ICP-AES)	100	10	10	0	0	0	120
	Mercury	Low	ISM02.2/CVAA	100	10	10	0	0	0	120
	Cyanide	Low	ISM02.2/Colorimetric	100	10	10	0	0	0	120
	GRO DRO/ORO	Low	Katahdin SOP #CA-316 Katahdin SOP #CA-315	50	5	0	0	0	0	55
	CrVI	Low	Katahdin SOP #CA-625	10	1	0	0	0	0	11
	TEL	Low	TestAmerica-Buffalo SOP #BF-MB-010	10	1	0	0	0	0	11
GW	VOC	Low	SOM01.2 (SIM added)	10	2	0	1 per trip (est 2)	0	0	14
	SVOC	Low	SOM02.2 (SIM added)	10	1	0	0	0	0	11
	PCB	Low	SOM01.2	2	1	1	0	0	0	4
	Pesticides	Low	SOM01.2	2	1	1	0	0	0	4
	Metals	Low	ISM02.2/ICP-MS	10	1	1	0	0	0	12

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**QAPP Worksheet #20**  
**Field Quality Control Sample Summary Table**

<b>Matrix</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Analytical and Preparation SOP Reference</b>	<b>No. of Sampling Locations</b>	<b>No. of Field Duplicate Pairs</b>	<b>Inorganic No. of MS</b>	<b>No. of Trip Blanks</b>	<b>No. of Equip. Blanks</b>	<b>No. of PT Samples</b>	<b>Total No. of Samples to Lab</b>
	Mercury	Low	ISM02.2/CVAA	10	1	1	0	0	0	12
	CrVI	Low	Katahdin SOP #CA-772	2	1	0	0	0	0	3
	TEL	Low	TestAmerica-Buffalo SOP #BF-MB-010	2	1	0	0	0	0	3

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**QAPP Worksheet #21**  
**Project Sampling SOP References Table**

Reference Number	Title, Revision Date and/or Number	Originating Organization	Equipment Type	Modified for Project Work? (Y/N)	Comments
1720	Operation of the Niton XLT 792YW Field Portable X-Ray Fluorescence Unit	SERAS	Field X-ray Fluorescence Analyzer	N	
2001	General Field Sampling Guidelines	SERAS	General Sampling	N	
2002	Sample Documentation	SERAS	NA	N	
2003	Sample Storage, Preservation and Handling	SERAS	Sample Handling	N	
2004	Sample Packaging and Shipment	SERAS	Sample Handling	N	
2005	Quality Assurance/Quality Control Samples	SERAS	NA	N	
2006	Sampling Equipment Decontamination	SERAS	Sampling Equipment	N	
2012	Soil Sampling	SERAS	Sampling Equipment	N	
2007	Groundwater Sampling	SERAS	Sampling Equipment	N	
2075	Description and Identification of Soils	SERAS	Soil Sampling	N	
4001	Logbook Documentation	SERAS	Site Activities	N	
4005	Chain of Custody Procedures	SERAS	Sample Handling	N	
NA	Field Operations Procedure – Integrated Cone Penetration Testing (CPT) and Rapid Optical Screening Tool (ROST™) Laser Induced Fluorescence (CPT/ROST™)	Fugro Consultants, Inc.	CPT/ROST	N	

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**QAPP Worksheet #22**  
**Field Equipment Calibration, Maintenance, Testing, and Inspection Table**

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference <sup>1</sup>
NITON XLt792YW	NA	Check condition of connectors and cables	NA	NA	With each use	Good condition	Replace or send in for factory service	XRF Analyst	1720
	Check energy calibration	NA	Perform energy calibration	NA	With each use and every 4 to 6 hours during sample analysis	Proper calibration	Power down, power up, logon, wait 10 minutes, re-check calibration; if continues to fail, send in for factory service	XRF Analyst	1720
	Check resolution	NA	After energy calibration	NA	With each use	Consistent with previous performance, typically less than 250 eV	If significantly higher than 250 eV, check SRMs and/or send in for factory service	XRF Analyst	1720
	NA	Check battery condition	NA	NA	With each use	Charged	Replace and/or charge as necessary	XRF Analyst	1720
	Check zero sample	NA	Analyze SiO <sub>2</sub> or sand blank	NA	With each use	All results non-detects	Repeat, if continues to fail, check SRMs and/or send in for factory service/calibration	XRF Analyst	1720
	Check target element response with reference standard	NA	Analyze reference standards	NA	With each use	Element results typically within $\pm 20\%$ of true values for concentrations 5x RL. For ERA SRM, %RSD $\pm 20\%$	Repeat. If still fails, send in for factory service/calibration	XRF Analyst	1720
Global Positioning System Receiver	NA	Keep GPS Clean and Charged	Verify operation	Prior to deployment visual inspection	Daily	Varies with satellite reception.	Charge Batteries/ Replace	TL	Manufacturer's manual
CPT/ROST	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP	Per Fugro SOP

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<b>Field Equipment</b>	<b>Calibration Activity</b>	<b>Maintenance Activity</b>	<b>Testing Activity</b>	<b>Inspection Activity</b>	<b>Frequency</b>	<b>Acceptance Criteria</b>	<b>Corrective Action</b>	<b>Responsible Person</b>	<b>SOP Reference<sup>1</sup></b>
MultiRAE electrochemical sensors	Zero and Span Cal	Check raw sensor readings quarterly or as needed, download and clear datalogger	Bump	Check keypad, LCD screen working, check datalogger check charcoal filter is in place	Calibrate before use/monthly/as needed	+/- 10%	Check gas concentration. Recalibrate, check sensor expiration, check raw sensor readings, replace sensor	Field Personnel	2139 and manufacturer's technical note TN-114, Sensor Specifications and Cross Sensitivities

<sup>1</sup>Specify the appropriate reference letter or number from the Project Sampling SOP References table (Worksheet #21).

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### QAPP Worksheet #23 Analytical SOP References Table

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
SOM02.2	<i>EPA CLP Program SOW for Organic Superfund Methods Multi-Media, Multi-Concentration</i>	Definitive	VOC (Soil)	GC-MS	CLP Designated Laboratory	<input type="checkbox"/>
SOM02.2	<i>EPA CLP Program SOW for Organic Superfund Methods Multi-Media, Multi-Concentration</i>	Definitive	SVOC	GC-MS	CLP Designated Laboratory	<input checked="" type="checkbox"/> (SIM Added)
SOM01.2	<i>EPA CLP Program SOW for Organic Superfund Methods Multi-Media, Multi-Concentration</i>	Definitive	VOC (Water), PCB/Pesticides	GC-MS	CLP Designated Laboratory	<input checked="" type="checkbox"/> (SIM Added)
ISM02.2	<i>EPA CLP Program SOW for Organic Superfund Methods Multi-Media, Multi-Concentration</i>	Definitive	Metals including Hg and CN	ICP-MS/ICP-AES/ CVAA	CLP Designated Laboratory	<input type="checkbox"/>
Katahdin SOP #CA-326	<i>Method for Determining Volatile Petroleum Hydrocarbons or Gasoline Range Organics (GRO) by Method 8015</i>	Screening	GRO	GC	Katahdin	<input type="checkbox"/>
Katahdin SOP #CA-315	<i>Determination of Extractable Petroleum Hydrocarbons by Methods 8015, 8100</i>	Screening	DRO/ORO	GC	Katahdin	<input type="checkbox"/>
Katahdin SOP #CA-772	<i>Colorimetric Analysis of Hexavalent Chromium Using the Automated Konelab Multiwavelength Photometric Analyzer</i>	Definitive	CrVI	Spectro-photometer	Katahdin	<input type="checkbox"/>
Katahdin SOP # CA-625	<i>Alkaline Digestion and Subsequent Determination of Hexavalent Chromium in Solid Samples Using EPA SW846 Methods 3060 and 7196</i>	Definitive	CrVI	Spectro-photometer	Katahdin	<input type="checkbox"/>

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**QAPP Worksheet #23**  
**Analytical SOP References Table**

Reference Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Analytical Group	Instrument	Organization Performing Analysis	Modified for Project Work?
TestAmerica – Buffalo SOP #BF-MB-010	<i>Analytical Methods for GC/MS Semivolatile Samples by SW846 8270D</i>	Definitive	TEL	GC-MS	TestAmerica	<input checked="" type="checkbox"/> (for TEL)
SERAS SOP #1720	<i>Operation of the Niton XLT 792YW Field Portable X-Ray Fluorescence Unit, Revision 2, 12/7/12</i>	Screening	Metals	Field X-ray Fluorescence Analyzer	SERAS	<input type="checkbox"/>

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**QAPP Worksheet #24**  
**Analytical Instrument Calibration Table**

<b>Instrument</b>	<b>Calibration Procedure</b>	<b>Frequency of Calibration</b>	<b>Acceptance Criteria</b>	<b>Corrective Action (CA)</b>	<b>Person Responsible for CA</b>	<b>SOP Reference</b>
GC/MS	See SOM01.2 and SOM02.2	Initial calibration: upon award of the contract, whenever the laboratory takes corrective action which may change or affect the initial calibration criteria (e.g., ion source cleaning or repair, column replacement, etc.), or if the continuing calibration acceptance criteria have not been met. Continuing calibration: Once every 12 hours	Initial calibration/ Continuing calibration: relative response factor (RRF) greater than or equal to minimum acceptable response factor listed in Table 5 of procedure; %RSD must be less than or equal to value listed in Table 5 of procedure.	Initial calibration: inspect system for problems (e.g., clean ion source, change the column, service the purge and trap device), correct problem, re-calibrate. Continuing calibration: inspect system, recalibrate the instrument, reanalyze samples.	EPA CLP RAS Laboratory GC/MS Technician	SOM01.2 and SOM02.2
GC/ECD	See SOM01.2	Initial calibration: upon award of the contract, whenever major instrument maintenance or modification is performed or if the calibration verification technical acceptance criteria have not been met. Calibration verification: Once every 12 hours	Initial calibration/ Calibration verification: resolution between two adjacent peaks must be greater than or equal to 60.0 percent, single components must be greater than or equal to 90.0 percent resolved, RTs within the RT window, %D must be greater than or equal to - 25 percent and less than or equal to 25 percent, %RSD must be less than or equal to 20.0 percent.	Initial calibration: inspect the system (e.g., change the column, bake out the detector, clean the injection port), correct problem, re-calibrate. Calibration verification: inspect system, recalibrate the instrument, reanalyze samples.	EPA CLP RAS Laboratory GC/ECD Technician	SOM01.2

**QAPP Worksheet #24**  
**Analytical Instrument Calibration Table**

<b>Instrument</b>	<b>Calibration Procedure</b>	<b>Frequency of Calibration</b>	<b>Acceptance Criteria</b>	<b>Corrective Action (CA)</b>	<b>Person Responsible for CA</b>	<b>SOP Reference</b>
ICP-AES / ICP-MS	See ISM02.2 ; as per instrument manufacturer's recommended procedures	ICP-AES or ICP-MS Initial calibration: daily or once every 24 hours and each time the instrument is set up. ICP-AES or ICP-MS Continuing calibration: beginning and end of run, and frequency of 10% or every 2 hours during an analysis run.	ICP-AES: As per instrument manufacturer's recommended procedures, with at least 2 standards. ICP-MS: As per instrument manufacturer's recommended procedures, with at least 2 standards. A minimum of three replicate integrations are required for data acquisition.	ICP-AES or ICP-MS: inspect the system, correct problem, re-calibrate, re-analyze samples.	EPA CLP RAS Laboratory ICP-AES / ICP-MS Technician	ISM02.2
CVAA	See ISM02.2 ; as per instrument manufacturer's recommended procedures	Each instrument shall be calibrated daily or once every 24 hours, each time the instrument is set up, or after ICV, ICB, Continuing Calibration Verification (CCV), or CCB failure.	At least six calibration standards shall be used. One of the standards shall be a blank standard and one shall be at or below the CRQL, but greater than the MDL. The rest of the standards shall be uniformly spread out in graduated amounts over the appropriate calibration range.	Any changes or corrections to the analytical system shall be followed by recalibration. The analysis shall be terminated, the problem corrected, the instrument recalibrated, and the calibration verified and reanalysis of all analytical samples analyzed since the last compliant calibration verification shall be performed.	EPA CLP RAS Laboratory ICP-AES / ICP-MS Technician	ISM02.2
Spectrophotometer	See ISM02.2 ; as per instrument manufacturer's recommended procedures	Each instrument shall be calibrated daily or once every 24 hours, each time the instrument is set up, or after ICV, ICB, Continuing Calibration Verification (CCV), or CCB failure.	At least six calibration standards shall be used. One of the standards shall be a blank standard and one shall be at or below the Contract Required Quantitation Limit (CRQL), but greater than the MDL. The rest of the standards shall be uniformly spread over the	Any changes or corrections to the analytical system shall be followed by recalibration. The analysis shall be terminated, the problem corrected, the instrument recalibrated, and the calibration verified and reanalysis of all analytical samples	EPA CLP RAS Laboratory ICP-AES / ICP-MS Technician	ISM02.2

Instrument	Calibration Procedure	Frequency of Calibration	Acceptance Criteria	Corrective Action (CA)	Person Responsible for CA	SOP Reference
			appropriate calibration range.	analyzed since the last compliant calibration verification shall be performed.		
Spectrophotometer	Katahdin SOP #CA-625	ICAL prior to analysis (quarterly) Initial calibration verification (ICV) following ICAL CCV every 10 samples	$r \geq 0.995$ ICV – 90-110% CCV $\pm 10\%$	Correct problem and recalibrate	Katahdin Analyst	Katahdin SOP #CA-625
Spectrophotometer	Katahdin SOP #CA-625	ICAL prior to analysis (daily) Initial calibration verification (ICV) following ICAL CCV every 10 samples	$r \geq 0.995$ ICV – 90-110% CCV $\pm 10\%$	Correct problem and recalibrate	Katahdin Analyst	Katahdin SOP #CA-772
GC (FID or FID/PID)	Katahdin SOP #CA-316	Prior to analysis or when continuing calibration fails	$r \geq 0.995$ $\%D \pm 20\%$	Perform instrument maintenance; reanalyze the ICAL	Katahdin Analyst	Katahdin SOP #CA-316
GC (FID)	Katahdin SOP #315	Initial calibration prior to analysis Discrimination Check (beginning of 12-hour shift) ICV CV every 10 samples	$r \geq 0.995$ $\%D \pm 20\%$ $\%D \pm 20\%$ $\%D \pm 20\%$	Perform instrument maintenance, reanalyze as needed	Katahdin Analyst	Katahdin SOP #CA-315
GC/MS	Test America SOP #BF-MB-010	DFTPP Tune every 12-hours ICAL prior initial analysis, when maintenance has been done or CCV does not pass ICV following ICAL CCV every 12-hours	Meet criteria in SOP for both abundance and GC column performance $\%RSD < 20\%$ (ICAL) $\%R = 70-130\%$ with the exceptions in Table 5 of the SOP (ICV) $\%D \pm 20\%$	Perform instrument maintenance, reanalyze as needed	TestAmerica Analyst	TestAmerica SOP #BF-MB-010

### QAPP Worksheet #25

#### Analytical Instrument and Equipment Maintenance, Testing, and Inspection Table

Instrument/ Equipment	Maintenance Activity	Testing/Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference <sup>1</sup>
GC/MS	See SOM01.2 or 02.2; as per instrument manufacturer's recommendations	See SOM01.2 or 02.2; as per instrument manufacturer's recommendations	See SOM01.2 or 02.2; as per instrument manufacturer's recommendations	Acceptable re-calibration; see SOM01.2 or 02.2	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	EPA CLP RAS Laboratory GC/MS Technician	SOM01.2 SOM02.2
GC/ECD	See SOM01.2; as per instrument manufacturer's recommendations	See SOM01.2; as per instrument manufacturer's recommendations	See SOM01.2; as per instrument manufacturer's recommendations	Acceptable re-calibration; see SOM01.2	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	EPA CLP RAS Laboratory GC/ECD Technician	SOM01.2
ICP-AES / ICP-MS	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	Acceptable re-calibration; see ISM02.2	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	EPA CLP RAS Laboratory ICP-AES / ICP-MS Technician	ISM02.2
Spectrophotometer	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	Acceptable re-calibration; see ISM02.2	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	EPA CLP RAS Laboratory ICP-AES / ICP-MS Technician	ISM02.2
Spectrophotometer	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	As per Katahdin SOP #CA-625 and CA-772	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Katahdin Analyst	Katahdin SOP #CA-625 and CA-772
GC/FID	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	As per Katahdin SOP #CA-315 and CA-316	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	Katahdin Analyst	Katahdin SOP #CA-315 and CA-316
GC/MS	As per instrument manufacturer's recommendations	As per instrument manufacturer's recommendations; check connections	As per instrument manufacturer's recommendations	As per Katahdin SOP #CA-315 and CA-316	Inspect the system, correct problem, re-calibrate and/or reanalyze samples.	TestAmerica Analyst	TestAmerica SOP #BF-MB-010

**QAPP Worksheet #26**  
**Sample Handling System**

<b>SAMPLE COLLECTION, PACKAGING, AND SHIPMENT</b>
Sample Collection (Personnel/Organization): Jon McBurney, Chris French, Amanda Wagner/ SERAS
Sample Packaging (Personnel/Organization): Jon McBurney, Chris French, Amanda Wagner/ SERAS
Coordination of Shipment (Personnel/Organization): Jon McBurney/ SERAS
Type of Shipment/Carrier: Federal Express or Dedicated Courier
<b>SAMPLE RECEIPT AND ANALYSIS</b>
Sample Receipt (Personnel/Organization): Sample Custodian, Katahdin Analytical; Sample Custodian, CLP Designated Laboratory
Sample Custody and Storage (Personnel/Organization): Sample Custodian, Katahdin Analytical; Sample Custodian, CLP Designated Laboratory
Sample Preparation (Personnel/Organization): Sample Prep Chemist, Katahdin or CLP Designated Laboratory
Sample Determinative Analysis (Personnel/Organization): ICP or GC Chemist, CLP Designated Laboratory; Chemist, Katahdin Analytical
<b>SAMPLE ARCHIVING</b>
Field Sample Storage (No. of days from sample collection): Samples will be held on-site in a locked area on ice for a maximum of 7 days for SVOCs, Metals, PCBs, Pesticides, GRO/DRO/ORO and TEL. All VOC and CrVI samples will be shipped daily.
Sample Extract/Digestate Storage (No. of days from extraction/digestion): As per individual analytical methods listed on Worksheet 23.
Biological Sample Storage (No. of days from sample collection): Not Applicable
<b>SAMPLE DISPOSAL</b>
Personnel/Organization: CLP Designated Laboratory or Katahdin Analytical waste coordinator
Number of Days from Analysis: Per analytical method.

## **QAPP Worksheet #27**

### **Sample Custody Requirements**

<b>Field Sample Custody Procedures (sample collection, packaging, shipment, and delivery to laboratory):</b>
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Chain of custody records will be generated for all samples submitted for analysis per SERAS SOP #4005, <i>Chain of Custody Procedures</i> . Each sample will be individually labelled, and sealed. Sample containers will be placed into Ziploc™ storage bags and then into a shipping cooler with the corresponding COC record. All samples will be stored per SERAS SOP# 2003, <i>Sample Storage, Preservation and Handling</i> . Samples will be shipped to the appropriate laboratory via overnight delivery service or courier per SERAS SOP#2004, <i>Sample Packaging and Shipment</i> .
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<b>Laboratory Sample Custody Procedures (receipt of samples, archiving, disposal):</b>
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A sample custodian at the laboratory will accept custody of the shipped samples, and check them for discrepancies, proper preservation, integrity, etc. If noted, issues will be forwarded to the laboratory manager for corrective action. The sample custodian will relinquish custody to the appropriate department of analysis.
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<b>Sample Identification Procedures:</b>
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Sample identifications will be in accordance with SERAS SOP #2002, <i>Sample Documentation</i> .
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<b>Chain-of-custody Procedures:</b>
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The chain-of-custody records will include, at a minimum, sample identification number, number of samples collected, sample collection date and time, sample type, sample matrix, sample container type, sample analysis requested, sample preservation, and the name(s) and signature(s) of samplers and all individuals who have had custody. Custody seals will demonstrate that a sample container or cooler has not been opened or tampered with. The sampler will sign and date the custody seal and affix it to the container or cooler in such a manner that it cannot be opened without breaking the seal.
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### QAPP Worksheet #28-1 QC Samples Table

<b>Matrix</b>	Aqueous							
<b>Analytical Group</b>	Target Compound List Trace Concentration Volatile Organics							
<b>Concentration Level</b>	Trace (ug/L)							
<b>Sampling SOP(s)</b>	SERAS SOP #2007							
<b>Analytical Method/SOP Reference</b>	SOM01.2							
<b>Sampler's Name</b>	McBurney, French, Wagner							
<b>Field Sampling Organization</b>	SERAS							
<b>Analytical Organization</b>	EPA CLP RAS Laboratory							
<b>No. of Sample Locations</b>	TBD							
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 every 12 hours	No analyte > CRQL*		Suspend analysis; reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	No analyte > CRQL*	
Matrix Spike (Not Required)	1 per ≤ 20 samples; if requested	1,1-Dichloroethene	61-145 %R	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,1-Dichloroethene	61-145 %R
		Benzene	76-127 %R				Benzene	76-127 %R
		Trichloroethene	71-120 %R				Trichloroethene	71-120 %R
		Toluene	76-125 %R				Toluene	76-125 %R
		Chlorobenzene	75-130 %R				Chlorobenzene	75-130 %R
Matrix Spike Duplicate (Not Required)	1 per ≤ 20 samples; if requested	1,1-Dichloroethene	0-14 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Precision	1,1-Dichloroethene	0-14 %RPD
		Benzene	0-11 %RPD				Benzene	0-11 %RPD
		Trichloroethene	0-14 %RPD				Trichloroethene	0-14 %RPD
		Toluene	0-13 %RPD				Toluene	0-13 %RPD
		Chlorobenzene	0-13 %RPD				Chlorobenzene	0-13 %RPD
Deuterated Monitoring Compounds	all samples	Vinyl chloride-d <sub>3</sub>	65-131 %R	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Vinyl chloride-d <sub>3</sub>	65-131 %R
		Chloroethane-d <sub>5</sub>	71-131 %R				Chloroethane-d <sub>5</sub>	71-131 %R

\*with the exception of methylene chloride, 2-butanone and acetone which can be up to 2 times the CRQL, or in some situations may require these compounds be up to 4 times the CRQL.

**QAPP Worksheet #28-1**  
**QC Samples Table**

<b>Matrix</b>		Aqueous							
<b>Analytical Group</b>		Target Compound List Trace Concentration Volatile Organics [cont'd]							
<b>Concentration Level</b>		Trace (ug/L)							
<b>Sampling SOP(s)</b>		SERAS SOP #2007							
<b>Analytical Method/SOP Reference</b>		SOM01.2							
<b>Sampler's Name</b>		McBurney, French, Wagner							
<b>Field Sampling Organization</b>		SERAS							
<b>Analytical Organization</b>		EPA CLP RAS Laboratory							
<b>No. of Sample Locations</b>		TBD							
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits							
Deuterated Monitoring Compounds [cont'd]	all samples	1,1-Dichloroethene-d <sub>2</sub>	55-104 %R	Check calculations and instruments, reanalyze affected samples; up to 3 DMCs per sample may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,1-Dichloroethene-d2	55-104 %R	
		2-Butanone-d <sub>5</sub>	49-155 %R				2-Butanone-d5	49-155 %R	
		Chloroform-d	78-121 %R				Chloroform-d	78-121 %R	
		1,2-Dichloroethane-d <sub>4</sub>	78-129 %R				1,2-Dichloroethane-d4	78-129 %R	
		Benzene-d <sub>6</sub>	77-124 %R				Benzene-d6	77-124 %R	
		1,2-Dichloropropane-d <sub>6</sub>	79-124 %R				1,2-Dichloropropane-d6	79-124 %R	
		Toluene-d <sub>8</sub>	77-121 %R				Toluene-d8	77-121 %R	
		trans-1,3-Dichloropropene-d <sub>4</sub>	73-121 %R				trans-1,3- Dichloropropene-d4	73-121 %R	
		2-Hexanone-d <sub>5</sub>	28-135 %R				2-Hexanone-d5	28-135 %R	
		1,4-Dioxane-d <sub>8</sub>	50-150 %R				1,4-Dioxane-d8	50-150 %R	
		1,1,2,2-Tetrachloroethane-d <sub>2</sub>	73-125 %R				1,1,2,2- Tetrachloroethane-d2	73-125 %R	

**QAPP Worksheet #28-1**  
**QC Samples Table**

<b>Matrix</b>		Aqueous						
<b>Analytical Group</b>		Target Compound List Trace Concentration Volatile Organics [cont'd]						
<b>Concentration Level</b>		Trace (ug/L)						
<b>Sampling SOP(s)</b>		SERAS SOP #2007						
<b>Analytical Method/SOP Reference</b>		SOM01.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Deuterated Monitoring Compounds [cont'd]	all samples	1,2-Dichlorobenzene- d <sub>4</sub>	80-131 %R	Check calculations and instruments, reanalyze affected samples; up to 3 DMCs per sample may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,2-Dichlorobenzene-d4	80-131 %R
Internal Standards	all samples	60-140%		Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	± 40 % of response area, ± 20 sec retention time shift	
Field Duplicate	1:20 samples	NA		Discuss in final deliverable	Task Leader	Precision	RPD ±20%	

## QAPP Worksheet #28-2

### QC Samples Table

<b>Matrix</b>		Aqueous						
<b>Analytical Group</b>		Target Compound List Volatile Organics						
<b>Concentration Level</b>		Low (ug/L)						
<b>Sampling SOP(s)</b>		SERAS SOP #2007						
<b>Analytical Method/SOP Reference</b>		SOM01.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
<b>Lab QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>						
Method Blank	1 every 12 hours	No analyte > CRQL*		Suspend analysis; reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	No analyte > CRQL*	
Matrix Spike (Not Required)	1 per ≤ 20 samples; if requested	1,1-Dichloroethene	61-145 %R	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,1-Dichloroethene	61-145 %R
		Benzene	76-127 %R				Benzene	76-127 %R
		Trichloroethene	71-120 %R				Trichloroethene	71-120 %R
		Toluene	76-125 %R				Toluene	76-125 %R
		Chlorobenzene	75-130 %R				Chlorobenzene	75-130 %R
Matrix Spike Duplicate (Not Required)	1 per ≤ 20 samples; if requested	1,1-Dichloroethene	0-14 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Precision	1,1-Dichloroethene	0-14 %RPD
		Benzene	0-11 %RPD				Benzene	0-11 %RPD
		Trichloroethene	0-14 %RPD				Trichloroethene	0-14 %RPD
		Toluene	0-13 %RPD				Toluene	0-13 %RPD
		Chlorobenzene	0-13 %RPD				Chlorobenzene	0-13 %RPD
Deuterated Monitoring Compounds	all samples	Vinyl chloride-d <sub>3</sub>	65-131 %R	Check calculations and instruments, reanalyze affected samples; see asterisk below	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Vinyl chloride-d <sub>3</sub>	65-131 %R
		Chloroethane-d <sub>5</sub>	71-131 %R				Chloroethane-d <sub>5</sub>	71-131 %R

\*with the exception of methylene chloride, 2-butanone and acetone which can be up to 2 times the CRQL.

**QAPP Worksheet #28-2**  
**QC Samples Table**

<b>Matrix</b>		Aqueous						
<b>Analytical Group</b>		Target Compound List Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low (ug/L)						
<b>Sampling SOP(s)</b>		SERAS SOP #2007						
<b>Analytical Method/SOP Reference</b>		SOM01.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
<b>Lab QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>		<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>	
Deuterated Monitoring Compounds [cont'd]	all samples	1,1-Dichloroethene-d <sub>2</sub>	55-104 %R	Check calculations and instruments, reanalyze affected samples; *up to 3 DMCs per sample may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,1-Dichloroethene-d <sub>2</sub>	55-104
		2-Butanone-d <sub>5</sub>	49-155 %R				2-Butanone-d <sub>5</sub>	49-155
		Chloroform-d	78-121 %R				Chloroform-d	78-121
		1,2-Dichloroethane-d <sub>4</sub>	78-129 %R				1,2-Dichloroethane-d <sub>4</sub>	78-129
		Benzene-d <sub>6</sub>	77-124 %R				Benzene-d <sub>6</sub>	77-124
		1,2-Dichloropropane-d <sub>6</sub>	79-124 %R				1,2-Dichloropropane-d <sub>6</sub>	79-124
		Toluene-d <sub>8</sub>	77-121 %R				Toluene-d <sub>8</sub>	77-121
		trans-1,3-Dichloropropene-d <sub>4</sub>	73-121 %R				trans-1,3-Dichloropropene-d <sub>4</sub>	73-121
		2-Hexanone-d <sub>5</sub>	28-135 %R				2-Hexanone-d <sub>5</sub>	28-135
		1,4-Dioxane-d <sub>8</sub>	50-150 %R				1,4-Dioxane-d <sub>8</sub>	50-150
		1,1,2,2-Tetrachloroethane-d <sub>2</sub>	73-125 %R				1,1,2,2-Tetrachloroethane-d <sub>2</sub>	73-125

**QAPP Worksheet #28-2**  
**QC Samples Table**

<b>Matrix</b>		Aqueous						
<b>Analytical Group</b>		Target Compound List Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low (ug/L)						
<b>Sampling SOP(s)</b>		SERAS SOP #2007						
<b>Analytical Method/SOP Reference</b>		SOM01.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
<b>Lab QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>		<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>	
Deuterated Monitoring Compounds [cont'd]	all samples	1,2-Dichlorobenzene-d4	80-131 %R	Check calculations and instruments, reanalyze affected samples; *up to 3 DMCs per sample may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,2-Dichlorobenzene-d4	80-131 %R
Internal Standards	all samples	50-200%		Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	± 40 % of response area, ± 20 sec retention time shift	
Field Duplicate	1:20 samples	NA		Discuss in final deliverable	Task Leader	Precision	RPD ±20%	

**QAPP Worksheet #28-3**  
**QC Samples Table**

Matrix		Aqueous						
Analytical Group		Target Compound List Semi-Volatile Organics						
Concentration Level		Low (ug/L)						
Sampling SOP(s)		SERAS SOP #2007						
Analytical Method/SOP Reference		SOM02.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 per ≤ 20 samples OR whenever samples extracted	No analyte > CRQL*		Suspend analysis; reextract and reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	No analyte > CRQL	
Matrix Spike (Not Required)	1 per ≤ 20 samples; if requested	Phenol	12-110 %R	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Phenol	12-110 %R
		2-Chlorophenol	27-123 %R				2-Chlorophenol	27-123 %R
		N-Nitroso-di-n-propylamine	41-116 %R				N-Nitroso-di-n-propylamine	41-116 %R
		4-Chloro-3-methylphenol	23-97 %R				4-Chloro-3-methylphenol	23-97 %R
		Acenaphthene	46-118 %R				Acenaphthene	46-118 %R
		4-Nitrophenol	10-80 %R				4-Nitrophenol	10-80 %R
		2,4-Dinitrotoluene	24-96 %R				2,4-Dinitrotoluene	24-96 %R
		Pentachlorophenol	9-103 %R				Pentachlorophenol	9-103 %R
		Pyrene	26-127 %R				Pyrene	26-127 %R

\*with the exception of bis (2-Ethylhexyl) phthalate which can be up to 5 times the CRQL.

**QAPP Worksheet #28-3**  
**QC Samples Table**

Matrix		Aqueous						
Analytical Group		Target Compound List Semi-Volatile Organics [cont'd]						
Concentration Level		Low (ug/L)						
Sampling SOP(s)		SERAS SOP #2007						
Analytical Method/SOP Reference		SOM02.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Matrix Spike Duplicate (Not Required)	1 per ≤ 20 samples; if requested	Phenol	0-42 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Precision	Phenol	0-42 %RPD
		2-Chlorophenol	0-40 %RPD				2-Chlorophenol	0-40 %RPD
		N-Nitroso-di-n-propylamine	0-38 %RPD				N-Nitroso-di-n-propylamine	0-38 %RPD
		4-Chloro-3-methylphenol	0-42 %RPD				4-Chloro-3-methylphenol	0-42 %RPD
		Acenaphthene	0-31 %RPD				Acenaphthene	0-31 %RPD
		4-Nitrophenol	0-50 %RPD				4-Nitrophenol	0-50 %RPD
		2,4-Dinitrotoluene	0-38 %RPD				2,4-Dinitrotoluene	0-38 %RPD
		Pentachlorophenol	0-50 %RPD				Pentachlorophenol	0-50 %RPD
		Pyrene	0-31 %RPD				Pyrene	0-31 %RPD
Deuterated Monitoring Compounds	all samples	Phenol-d5	39-106 %R	Check calculations and instruments, reanalyze affected samples; up to 4 DMCs may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Phenol-d5	39-106 %R
		Bis(2-chloroethyl)ether-d8	40-105 %R				Bis(2-chloroethyl)ether-d8	40-105 %R
		2-Chlorophenol-d4	41-106 %R				2-Chlorophenol-d4	41-106 %R

**QAPP Worksheet #28-3**  
**QC Samples Table**

<b>Matrix</b>		Aqueous							
<b>Analytical Group</b>		Target Compound List Semi-Volatile Organics [cont'd]							
<b>Concentration Level</b>		Low (ug/L)							
<b>Sampling SOP(s)</b>		SERAS SOP #2007							
<b>Analytical Method/SOP Reference</b>		SOM02.2							
<b>Sampler's Name</b>		McBurney, French, Wagner							
<b>Field Sampling Organization</b>		SERAS							
<b>Analytical Organization</b>		EPA CLP RAS Laboratory							
<b>No. of Sample Locations</b>		TBD							
<b>Lab QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>							
Deuterated Monitoring Compounds [cont'd]	all samples	4-Methylphenol-d8	25-111 %R	Check calculations and instruments, reanalyze affected samples; up to 4 DMCs may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	4-Methylphenol-d8	25-111 %R	
		Nitrobenzene-d5	43-108 %R				Nitrobenzene-d5	43-108 %R	
		2-Nitrophenol-d4	40-108 %R				2-Nitrophenol-d4	40-108 %R	
		2,4-Dichlorophenol-d3	37-105 %R				2,4-Dichlorophenol-d3	37-105 %R	
		4-Chloroaniline-d4	1-145 %R				4-Chloroaniline-d4	1-145 %R	
		Dimethylphthalate-d6	47-114 %R				Dimethylphthalate-d6	47-114 %R	
		Acenaphthylene-d8	41-107 %R				Acenaphthylene-d8	41-107 %R	
		4-Nitrophenol-d4	33-116 %R				4-Nitrophenol-d4	33-116 %R	
		Fluorene-d10	42-111 %R				Fluorene-d10	42-111 %R	
		4,6-Dinitro-2-methylphenol-d2	22-104 %R				4,6-Dinitro-2-methylphenol-d2	22-104 %R	
		Anthracene-d10	44-110 %R				Anthracene-d10	44-110 %R	
		Pyrene-d10	52-119 %R				Pyrene-d10	52-119 %R	
		Fluoranthene-d10 (SIM)	50-150 %R				Fluoranthene-d10 (SIM)	50-150 %R	
		2-Methylnapthalene-d10 (SIM)	50-150 %R				2-Methylnapthalene-d10 (SIM)	50-150 %R	

### QAPP Worksheet #28-3

#### QC Samples Table

<b>Matrix</b>		Aqueous						
<b>Analytical Group</b>		Target Compound List Semi-Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low (ug/L)						
<b>Sampling SOP(s)</b>		SERAS SOP #2007						
<b>Analytical Method/SOP Reference</b>		SOM02.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Deuterated Monitoring Compounds [cont'd]	all samples	Benzo(a)pyrene-d12	32-121 %R	Check calculations and instruments, reanalyze affected samples; up to 4 DMCs may fail to meet recovery limits	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Benzo(a)pyrene-d12	32-121 %R
Internal Standards	all samples	50-100% of area, ± 30 sec retention time shift		Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	50-100% of area, ± 20 sec retention time shift	
Field Duplicate	1:20 samples	NA		Discuss in final deliverable	Task Leader	Precision	RPD ±20%	

**QAPP Worksheet #28-4**  
**QC Samples Table**

<b>Matrix</b>	Aqueous							
<b>Analytical Group</b>	Target Compound List Pesticides							
<b>Concentration Level</b>	Low (ug/L)							
<b>Sampling SOP(s)</b>	SERAS SOP #2007							
<b>Analytical Method/SOP Reference</b>	SOM01.2							
<b>Sampler's Name</b>	McBurney, French, Wagner							
<b>Field Sampling Organization</b>	SERAS							
<b>Analytical Organization</b>	EPA CLP RAS Laboratory							
<b>No. of Sample Locations</b>	TBD							
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>		<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>	
Method Blank	1 per ≤ 20 samples OR whenever samples extracted	No analyte > CRQL		Suspend analysis; reextract and reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	No analyte > CRQL	
Matrix Spike	1 per ≤ 20 samples; if requested	gamma-BHC (Lindane)	56-123 %R	Flag outliers	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	gamma-BHC (Lindane)	56-123 %R
		Heptachlor	40-131 %R				Heptachlor	40-131 %R
		Aldrin	40-120 %R				Aldrin	40-120 %R
		Dieldrin	52-126 %R				Dieldrin	52-126 %R
		Endrin	56-121 %R				Endrin	56-121 %R
		4,4'-DDT	38-127 %R				4,4'-DDT	38-127 %R
Matrix Spike Duplicate	1 per ≤ 20 samples; if requested	gamma-BHC	0-15 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/ECD Technician	Precision	gamma-BHC	0-15 %RPD
		Heptachlor	0-20 %RPD				Heptachlor	0-20 %RPD
		Aldrin	0-22 %RPD				Aldrin	0-22 %RPD
		Dieldrin	0-18 %RPD				Dieldrin	0-18 %RPD
		Endrin	0-21 %RPD				Endrin	0-21 %RPD
		4,4'-DDT	0-27 %RPD				4,4'-DDT	0-27 %RPD
Laboratory Control Sample	1 per ≤ 20 samples	gamma-BHC	50-120 %R	Check calculations and instruments, reextract and reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	gamma-BHC	50-120 %R

**QAPP Worksheet #28-4**  
**QC Samples Table**

Matrix		Aqueous						
Analytical Group		Target Compound List Pesticides [cont'd]						
Concentration Level		Low (ug/L)						
Sampling SOP(s)		SERAS SOP #2007						
Analytical Method/SOP Reference		SOM01.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Laboratory Control Sample [cont'd]	1 per ≤ 20 samples	Heptachlor epoxide	50-150 %R	Check calculations and instruments, reextract and reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	Heptachlor epoxide	50-150 %R
		Dieldrin	30-130 %R				Dieldrin	30-130 %R
		4,4'-DDE	50-150 %R				4,4'-DDE	50-150 %R
		Endrin	50-120 %R				Endrin	50-120 %R
		Endosulfan sulfate	50-120 %R				Endosulfan sulfate	50-120 %R
		gamma-Chlordane	30-130 %R				gamma-Chlordane	30-130 %R
Surrogates	All Samples		30-150 %R	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	30-150 %R	
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD ±20%		

### QAPP Worksheet #28-5 QC Samples Table

Matrix		Aqueous						
Analytical Group		Target Compound List PCBs						
Concentration Level		Low (ug/L)						
Sampling SOP(s)		SERAS SOP #2007						
Analytical Method/SOP Reference		SOM01.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 per ≤ 20 samples OR whenever samples extracted	No analyte > CRQL		Suspend analysis; reextract and reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	No analyte > CRQL	
Matrix Spike	1 per ≤ 20 samples; if requested	Aroclor-1016	29-135 %R		EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	Aroclor-1016	29-135 %R
		Aroclor-1260	29-135 %R				Aroclor-1260	29-135 %R
Matrix Spike Duplicate	1 per ≤ 20 samples; if requested	Aroclor-1016	0-15 %RPD		EPA CLP RAS Laboratory GC/ECD Technician	Precision	Aroclor-1016	0-15 %RPD
		Aroclor-1260	0-20 %RPD				Aroclor-1260	0-20 %RPD
Laboratory Control Sample	1 per ≤ 20 samples	Aroclor-1016	50-150 %R		EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	Aroclor-1016	50-150 %R
		Aroclor-1260	50-150 %R				Aroclor-1260	50-150 %R
Surrogates	all samples		30-150 %R		EPA CLP RAS Laboratory GC/ECD Technician	Accuracy		30-150 %R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD ±20%		

**QAPP Worksheet #28-6**  
**QC Samples Table**

<b>Matrix</b>	Aqueous					
<b>Analytical Group</b>	Target Analyte List Inorganics Metals					
<b>Concentration Level</b>	Low (ug/L)					
<b>Sampling SOP(s)</b>	SERAS SOP #2007					
<b>Analytical Method/SOP Reference</b>	ISM02.2					
<b>Sampler's Name</b>	McBurney, French, Wagner					
<b>Field Sampling Organization</b>	SERAS					
<b>Analytical Organization</b>	EPA CLP RAS Laboratory					
<b>No. of Sample Locations</b>	TBD					
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Preparation Blank	1 per $\leq$ 20 samples	No constituent > CRQL	Suspend analysis until source rectified; redigest and reanalyze affected samples	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	No constituent > CRQL
Spike	1 per $\leq$ 20 samples	75-125%R*	Flag outliers	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	75-125%R*
Duplicate	1 per $\leq$ 20 samples	$\pm$ 20% RPD**	Flag outliers	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Precision	$\pm$ 20% RPD**
Post-Digestion Spike	after any analyte (except Ag) fails spike %R	75-125%R	Flag outliers	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	75-125%R
Interference Check Sample [ICP Analysis Only]	beginning of each run	Within $\pm$ (CRQL + true value) or $\pm$ 20% of true value, whichever is greater	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Sensitivity	Within $\pm$ (CRQL + true value) or $\pm$ 20% of true value, whichever is greater

\*except when the sample concentration is greater than 4 times the spike concentration, then disregard the recoveries; no data validation action taken

\*\*except when the sample and/or duplicate concentration is less than 5 times the CRQL, then  $\pm$  CRQL.

**QAPP Worksheet #28-6**  
**QC Samples Table**

<b>Matrix</b>		Aqueous				
<b>Analytical Group</b>		Target Analyte List Inorganics Metals [cont'd]				
<b>Concentration Level</b>		Low (ug/L)				
<b>Sampling SOP(s)</b>		SERAS SOP #2007				
<b>Analytical Method/SOP Reference</b>		ISM02.2				
<b>Sampler's Name</b>		McBurney, French, Wagner				
<b>Field Sampling Organization</b>		SERAS				
<b>Analytical Organization</b>		EPA CLP RAS Laboratory				
<b>No. of Sample Locations</b>		TBD				
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Laboratory Control Sample	1 per $\leq$ 20 samples	70-130%R	Suspend analysis until source rectified; redigest and reanalyze affected samples	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	70-130%R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 20%

**QAPP Worksheet #28-7**  
**QC Samples Table**

<b>Matrix</b>	Aqueous					
<b>Analytical Group</b>	Target Analyte List Inorganics – Total Mercury					
<b>Concentration Level</b>	Low (ug/L)					
<b>Sampling SOP(s)</b>	SERAS SOP #2007					
<b>Analytical Method/SOP Reference</b>	ISM01.3 – Cold Vapor Atomic Absorption (CVAA)					
<b>Sampler's Name</b>	McBurney, French, Wagner					
<b>Field Sampling Organization</b>	SERAS					
<b>Analytical Organization</b>	EPA CLP RAS Laboratory					
<b>No. of Sample Locations</b>	TBD					
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Preparation Blank (PB)	1 per $\leq$ 20 samples	No analyte > CRQL	Suspend analysis; redigest and reanalyze	EPA CLP RAS Laboratory Technician	Accuracy	No analyte > CRQL
Duplicate Sample	1 per $\leq$ 20 samples	$\pm$ 20% RPD*	Flag outliers	EPA CLP RAS Laboratory Technician	Precision	$\pm$ 20% RPD
Spike Sample	1 per $\leq$ 20 samples	75 – 125 %R	Flag outliers	EPA CLP RAS Laboratory Technician	Accuracy	75 – 125 %R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 20%

**QAPP Worksheet #28-8**  
**QC Samples Table**

<b>Matrix</b>	Aqueous					
<b>Analytical Group</b>	Target Analyte List Inorganics - Total Cyanide					
<b>Concentration Level</b>	Low (ug/L)					
<b>Sampling SOP(s)</b>	SERAS SOP #2007					
<b>Analytical Method/SOP Reference</b>	ISM02.2 – Colorimeter or Spectrophotometer					
<b>Sampler's Name</b>	McBurney, French, Wagner					
<b>Field Sampling Organization</b>	SERAS					
<b>Analytical Organization</b>	EPA CLP RAS Laboratory					
<b>No. of Sample Locations</b>	TBD					
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Preparation Blank (PB)	1 per $\leq$ 20 samples	No analyte > CRQL	Suspend analysis; redistill and reanalyze	EPA CLP RAS Laboratory Technician	Accuracy	No analyte > CRQL
Duplicate Sample	1 per $\leq$ 20 samples	$\pm$ 20% RPD*	Flag outliers	EPA CLP RAS Laboratory Technician	Precision	$\pm$ 20% RPD
Spike Sample	1 per $\leq$ 20 samples	75 – 125 %R	Flag outliers	EPA CLP RAS Laboratory Technician	Accuracy	75 – 125 %R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 20%

### QAPP Worksheet #28-9 QC Samples Table

Matrix	Water					
Analytical Group	Cr(VI)					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2007					
Analytical Method/ SOP Reference	Katahdin SOP #CA-772					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	Katahdin Analytical					
No. of Sample Locations	TBD					
QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 in 20	RPD $\pm$ 20%	Document, report	Task Leader	Precision	RPD $\pm$ 20%
LCS	1 per digestion batch of 20 or fewer samples	%R = 90-110%	Investigate source of problem; re- digest & re- analyze batch	Analyst	Accuracy	%R = 90-110
Laboratory Duplicate or MSD	1 per digestion batch of 10 or fewer samples	RPD $\pm$ 20%, if both the sample and duplicate are $\geq$ four times the PQL	Flag results	Analyst	Precision	RPD $\pm$ 20%, if both the sample and duplicate are $\geq$ four times the PQL
Method Blank	One per batch of 20 samples/same matrix	< RL	Re-prep, re- analyze	Analyst	Accuracy/Bias	< RL
Matrix Spike	One per digestion batch of 10 or fewer samples	%R = 80-120 (SM 3500 Cr-B) %R = 85-115 (EPA 7196)	Evaluate the samples; if both LCS and MS are unacceptable, reprep the batch; dilute a new pH adjusted aliquot for 7196	Analyst	Accuracy	%R = 80-120 (SM 3500 Cr-B) %R = 85-115 (EPA 7196)
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 20%

**QAPP Worksheet #28-10**  
**QC Samples Table**

Matrix	Water					
Analytical Group	TEL					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2007					
Analytical Method/ SOP Reference	TestAmerica SOP #BF-MB-010					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	TestAmerica					
No. of Sample Locations	TBD					
<b>QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Field Duplicate	1 in 20	RPD: $\pm 20\%$	Document, report	Task Leader	Precision (Field)	RPD: $\pm 20\%$
MS	1 in 20	Within control chart limits	Limits are advisory; frequent occurrences require investigation	Analyst	Accuracy/Bias	Within control chart limits
MS/MSD	1 in 20	Within control chart limits	Limits are advisory; frequent occurrences require investigation	Analyst	Precision	Within control chart limits
LCS	1 in 20	Within control chart limits	Reanalyze. If still failing, reextract and reanalyze batch. If high bias and samples are non- detect, report sample results	Analyst	Accuracy/Bias	Within control chart limits
Surrogates	Every Sample	Within control chart limits	Re-inject and/or reanalyze	Analyst	Accuracy/Bias	Within control chart limits

**QAPP Worksheet #28-10**  
**QC Samples Table**

Matrix	Water					
Analytical Group	TEL					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2007					
Analytical Method/ SOP Reference	TestAmerica SOP #BF-MB-010					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	TestAmerica					
No. of Sample Locations	TBD					
<b>QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Method Blank	1 in 20	<RL	Investigate source of contamination, take and document corrective actions prior to sample analysis	Analyst	Accuracy/Bias Contamination	<RL
Internal Standards		50-200%	Re-inject to confirm	Analyst	Accuracy/Bias	50-200%
Field Blank		<RL	Document in final deliverable, flag data	Task Leader	Accuracy/Bias (Contamination)	<RL
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 20%

## QAPP Worksheet #28-11

### QC Samples Table

Matrix		Soil						
Analytical Group		Target Compound List Volatile Organics						
Concentration Level		Low/Medium (mg/kg)						
Sampling SOP(s)		SERAS SOP #2012						
Analytical Method/SOP Reference		SOM02.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 every 12 hours	No analyte > CRQL*		Suspend analysis; reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	No analyte > CRQL*	
Matrix Spike (Not Required)	1 per ≤ 20 samples; if requested	1,1-Dichloroethene	59-172 %R	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,1-Dichloroethene	59-172 %R
		Trichloroethene	62-137 %R				Trichloroethene	62-137 %R
		Benzene	66-142 %R				Benzene	66-142 %R
		Toluene	59-139 %R				Toluene	59-139 %R
		Chlorobenzene	60-133 %R				Chlorobenzene	60-133 %R
Matrix Spike Duplicate (Not Required)	1 per ≤ 20 samples; if requested	1,1-Dichloroethene	0-22 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Precision	1,1-Dichloroethene	0-22 %RPD
		Trichloroethene	0-24 %RPD				Trichloroethene	0-24 %RPD
		Benzene	0-21 %RPD				Benzene	0-21 %RPD
		Toluene	0-21 %RPD				Toluene	0-21 %RPD
		Chlorobenzene	0-21 %RPD				Chlorobenzene	0-21 %RPD
Deuterated Monitoring Compounds	all samples	Vinyl chloride-d3	68-122 %R	Check calculations and instruments, reanalyze affected samples up to 3 DMCs per sample may fail to meet necessary limits (Section 11.3.4, Page D45/SOM01.2)	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Vinyl chloride-d3	68-122 %R
		Chloroethane-d5	61-130 %R				Chloroethane-d5	61-130 %R

**QAPP Worksheet #28-11**  
**QC Samples Table**

<b>Matrix</b>		Soil						
<b>Analytical Group</b>		Target Compound List Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low/Medium (mg/kg)						
<b>Sampling SOP(s)</b>		SERAS SOP #2012						
<b>Analytical Method/SOP Reference</b>		SOM02.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>		<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>	
Deuterated Monitoring Compounds [cont'd]	all samples	1,1-Dichloroethene-d <sub>2</sub>	45-132 %R	Check calculations and instruments, reanalyze affected samples; up to 3 DMCs per sample may fail to meet necessary limits (Section 11.3.4, Page D45 of SOM01.2)	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,1-Dichloroethene-d <sub>2</sub>	45-132 %R
		2-Butanone-d <sub>5</sub>	20-182 %R				2-Butanone-d <sub>5</sub>	20-182 %R
		Chloroform-d	72-123 %R				Chloroform-d	72-123 %R
		1,2-Dichloroethane-d <sub>4</sub>	79-122 %R				1,2-Dichloroethane-d <sub>4</sub>	79-122 %R
		Benzene-d <sub>6</sub>	80-121 %R				Benzene-d <sub>6</sub>	80-121 %R
		1,2-Dichloropropane-d <sub>6</sub>	74-124 %R				1,2-Dichloropropane-d <sub>6</sub>	74-124 %R
		Toluene-d <sub>8</sub>	78-121 %R				Toluene-d <sub>8</sub>	78-121 %R
		trans-1,3-Dichloropropene-d <sub>4</sub>	72-130 %R				trans-1,3-Dichloropropene-d <sub>4</sub>	72-130 %R
		2-Hexanone-d <sub>5</sub>	17-184 %R				2-Hexanone-d <sub>5</sub>	17-184 %R
		1,4-Dioxane-d <sub>8</sub>	50-150 %R				1,4-Dioxane-d <sub>8</sub>	50-150 %R
		1,1,2,2-Tetrachloroethane-d <sub>2</sub>	56-161 %R				1,1,2,2-Tetrachloroethane-d <sub>2</sub>	56-161 %R

**QAPP Worksheet #28-11**  
**QC Samples Table**

<b>Matrix</b>		Soil						
<b>Analytical Group</b>		Target Compound List Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low/Medium (mg/kg)						
<b>Sampling SOP(s)</b>		SERAS SOP #2012						
<b>Analytical Method/SOP Reference</b>		SOM02.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
<b>Lab QC Sample:</b>	<b>Frequency/ Number</b>	<b>Method/SOP QC Acceptance Limits</b>		<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>	
Deuterated Monitoring Compounds [cont'd]	all samples	1,2-Dichlorobenzene-d <sub>4</sub>	70-131 %R	Check calculations and instruments, reanalyze affected samples; up to 3 DMCs per sample may fail to meet necessary limits (Section 11.3.4, Page D45/VOC of SOM01.2)	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	1,2-Dichlorobenzene-d <sub>4</sub>	70-131 %R
Internal Standards	all samples	50-200% of area, ± 30 sec retention time shift		Check calculations and instruments, reanalyze affected samples; up to 3 DMCs per sample may fail to meet necessary limits (Section 11.3.4, Page D45/VOC of SOM01.2)	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	50-100% of area, ± 30 sec retention time shift	
Field Duplicate	1:20 samples	NA		Discuss in final deliverable	Task Leader	Precision	RPD ±35%	

## QAPP Worksheet #28-12

### QC Samples Table

Matrix		Soil						
Analytical Group		Target Compound List Semi-Volatile Organics						
Concentration Level		Low/Medium (mg/kg)						
Sampling SOP(s)		SERAS SOP #2012						
Analytical Method/SOP Reference		SOM02.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 per ≤ 20 samples or whenever samples extracted	No analyte > CRQL*		Suspend analysis; reextract and reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	No analyte > CRQL*	
Matrix Spike (Not Required)	1 per ≤ 20 samples; if requested	Phenol	26-90 %R	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	Phenol	26-90 %R
		2-Chlorophenol	25-102 %R				2-Chlorophenol	25-102 %R
		N-Nitroso-di-n-propylamine	41-126 %R				N-Nitroso-di-n-propylamine	41-126 %R
		4-Chloro-3-methylphenol	26-103 %R				4-Chloro-3-methylphenol	26-103 %R
		Acenaphthene	31-137 %R				Acenaphthene	31-137 %R
		4-Nitrophenol	11-114 %R				4-Nitrophenol	11-114 %R
		2,4-Dinitrotoluene	28-89 %R				2,4-Dinitrotoluene	28-89 %R
		Pentachloro-phenol	17-109 %R				Pentachloro-phenol	17-109 %R
		Pyrene	35-142 %R				Pyrene	35-142 %R
		Matrix Spike Duplicate (Not Required)	1 per ≤ 20 samples; if requested				Phenol	0-35 %RPD
2-Chlorophenol	0-50 %RPD			2-Chlorophenol	0-50 %RPD			
N-Nitroso-di-n-propylamine	0-38 %RPD			N-Nitroso-di-n-propylamine	0-38 %RPD			

\*with the exception of bis (2-Ethylhexyl) phthalate which can be up to 5 times the CRQL

**QAPP Worksheet #28-12**  
**QC Samples Table**

<b>Matrix</b>		Soil						
<b>Analytical Group</b>		Target Compound List Semi-Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low/Medium (mg/kg)						
<b>Sampling SOP(s)</b>		SERAS SOP #2012						
<b>Analytical Method/SOP Reference</b>		SOM02.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Matrix Spike Duplicate (Not Required) [cont'd]	1 per ≤ 20 samples; if requested	4-Chloro-3-methylphenol	0-33 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/MS Technician	Precision	4-Chloro-3-methylphenol	0-33 %RPD
		Acenaphthene	0-19 %RPD				Acenaphthene	0-19 %RPD
		4-Nitrophenol	0-50 %RPD				4-Nitrophenol	0-50 %RPD
		2,4-Dinitrotoluene	0-47 %RPD				2,4-Dinitrotoluene	0-47 %RPD
		Pentachloro-phenol	0-47 %RPD				Pentachloro-phenol	0-47 %RPD
		Pyrene	0-36 %RPD				Pyrene	0-36 %RPD
		Deuterated Monitoring Compounds	all samples				Phenol-d <sub>5</sub>	17-103 %R
Bis(2-chloroethyl)ether-d <sub>8</sub>	12-98 %R			Bis(2-chloroethyl)ether-d <sub>8</sub>	12-98 %R			
2-Chlorophenol-d <sub>4</sub>	13-101 %R			2-Chlorophenol-d <sub>4</sub>	13-101 %R			
4-Methylphenol-d <sub>8</sub>	8-100 %R			4-Methylphenol-d <sub>8</sub>	8-100 %R			
Nitrobenzene-d <sub>5</sub>	16-103 %R			Nitrobenzene-d <sub>5</sub>	16-103 %R			
2-Nitrophenol-d <sub>4</sub>	16-104 %R			2-Nitrophenol-d <sub>4</sub>	16-104 %R			

## QAPP Worksheet #28-12

### QC Samples Table

<b>Matrix</b>		Soil						
<b>Analytical Group</b>		Target Compound List Semi-Volatile Organics [cont'd]						
<b>Concentration Level</b>		Low/Medium (mg/kg)						
<b>Sampling SOP(s)</b>		SERAS SOP #2012						
<b>Analytical Method/SOP Reference</b>		SOM01.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Deuterated Monitoring Compounds [cont'd]	all samples	2,4-Dichlorophenol-d <sub>3</sub>	23-104 %R	Check calculations and instruments, reanalyze affected samples; up to 4 DMCs may fail to meet recovery limits (Section 11.3.4, Page D48/SVOC of SOM01.2)	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	2,4-Dichlorophenol-d <sub>3</sub>	23-104 %R
		4-Chloroaniline-d <sub>4</sub>	1-145 %R				4-Chloroaniline-d <sub>4</sub>	1-145 %R
		Dimethylphthalate-d <sub>6</sub>	43-111 %R				Dimethylphthalate-d <sub>6</sub>	43-111 %R
		Acenaphthylene-d <sub>8</sub>	20-97 %R				Acenaphthylene-d <sub>8</sub>	20-97 %R
		4-Nitrophenol-d <sub>4</sub>	16-166 %R				4-Nitrophenol-d <sub>4</sub>	16-166 %R
		Fluorene-d <sub>10</sub>	40-108 %R				Fluorene-d <sub>10</sub>	40-108 %R
		4,6-Dinitro-2-methylphenol-d <sub>2</sub>	1-121 %R				4,6-Dinitro-2-methylphenol-d <sub>2</sub>	1-121 %R
		Anthracene-d <sub>10</sub>	22-98 %R				Anthracene-d <sub>10</sub>	22-98 %R
		Pyrene-d <sub>10</sub>	51-120 %R				Pyrene-d <sub>10</sub>	51-120 %R
		Benzo(a)pyrene-d <sub>12</sub>	43-111 %R				Benzo(a)pyrene-d <sub>12</sub>	43-111 %R
		Fluoranthene-d <sub>10</sub> (SIM)	50-150 %R				Fluoranthene-d <sub>10</sub> (SIM)	50-150 %R
		2-Methylnapthalene-d <sub>10</sub> (SIM)	50-150 %R				2-Methylnapthalene-d <sub>10</sub> (SIM)	50-150 %R

**QAPP Worksheet #28-12**  
**QC Samples Table**

<b>Matrix</b>		Soil				
<b>Analytical Group</b>		Target Compound List Semi-Volatile Organics [cont'd]				
<b>Concentration Level</b>		Low/Medium (mg/kg)				
<b>Sampling SOP(s)</b>		SERAS SOP #2012				
<b>Analytical Method/SOP Reference</b>		SOM02.2				
<b>Sampler's Name</b>		McBurney, French, Wagner				
<b>Field Sampling Organization</b>		SERAS				
<b>Analytical Organization</b>		EPA CLP RAS Laboratory				
<b>No. of Sample Locations</b>		TBD				
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Internal Standards	all samples	50-200% of area, $\pm$ 30 sec retention time shift	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/MS Technician	Accuracy	50-200% of area, $\pm$ 30 sec retention time shift
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 35%

**QAPP Worksheet #28-13**  
**QC Samples Table**

<b>Matrix</b>		Soil						
<b>Analytical Group</b>		Target Compound List Pesticides						
<b>Concentration Level</b>		Low/Medium (mg/kg)						
<b>Sampling SOP(s)</b>		SERAS SOP #2012						
<b>Analytical Method/SOP Reference</b>		SOM01.2						
<b>Sampler's Name</b>		McBurney, French, Wagner						
<b>Field Sampling Organization</b>		SERAS						
<b>Analytical Organization</b>		EPA CLP RAS Laboratory						
<b>No. of Sample Locations</b>		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 per ≤ 20 samples or whenever samples extracted	No analyte > CRQL		Suspend analysis; reextract and reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	No analyte > CRQL	
Matrix Spike	1 per ≤ 20 samples	gamma-BHC (Lindane)	46-127 %R	Flag outliers	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	gamma-BHC (Lindane)	46-127 %R
		Heptachlor	35-130 %R				Heptachlor	35-130 %R
		Aldrin	34-132 %R				Aldrin	34-132 %R
		Dieldrin	31-134 %R				Dieldrin	31-134 %R
		Endrin	42-139 %R				Endrin	42-139 %R
		4,4-DDT	23-134 %R				4,4-DDT	23-134 %R
Matrix Spike Duplicate	1 per ≤ 20 samples	gamma-BHC	0-50 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/ECD Technician	Precision	gamma-BHC	0-50 %RPD
		Heptachlor	0-31 %RPD				Heptachlor	0-31 %RPD
		Aldrin	0-43 %RPD				Aldrin	0-43 %RPD
		Dieldrin	0-38 %RPD				Dieldrin	0-38 %RPD
		Endrin	0-45 %RPD				Endrin	0-45 %RPD
		4,4-DDT	0-50 %RPD				4,4-DDT	0-50 %RPD

**QAPP Worksheet #28-13**  
**QC Samples Table**

Matrix		Soil						
Analytical Group		Target Compound List Pesticides [cont'd]						
Concentration Level		Low/Medium (mg/kg)						
Sampling SOP(s)		SERAS SOP #2012						
Analytical Method/SOP Reference		SOM01.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Laboratory Control Sample	all samples	gamma-BHC	50-120 %R	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	gamma-BHC	50-120 %R
		Heptachlor epoxide	50-150 %R				Heptachlor epoxide	50-150 %R
		Dieldrin	30-130 %R				Dieldrin	30-130 %R
		4,4'-DDE	50-150 %R				4,4'-DDE	50-150 %R
		Endrin	50-120 %R				Endrin	50-120 %R
		Endosulfan sulfate	50-120 %R				Endosulfan sulfate	50-120 %R
		gamma- Chlordane	30-130 %R				gamma- Chlordane	30-130 %R
Surrogate	all samples	30–150 %R		Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	30-150 %R	
Field Duplicate	1:20 samples	NA		Discuss in final deliverable	Task Leader	Precision	RPD ±35%	

## QAPP Worksheet #28-14

### QC Samples Table

Matrix		Soil						
Analytical Group		Target Compound List PCBs						
Concentration Level		Low/Medium (mg/kg)						
Sampling SOP(s)		SERAS SOP #2012						
Analytical Method/SOP Reference		SOM01.2						
Sampler's Name		McBurney, French, Wagner						
Field Sampling Organization		SERAS						
Analytical Organization		EPA CLP RAS Laboratory						
No. of Sample Locations		TBD						
Lab QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits		Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria	
Method Blank	1 per ≤ 20 samples or whenever samples extracted	No analyte > CRQL		Suspend analysis; reextract and reanalyze blank and affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	No analyte > CRQL	
Matrix Spike	1 per ≤ 20 samples	Aroclor-1016	29-135 %R	Flag outliers	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	Aroclor-1016	29-135 %R
		Aroclor-1260	29-135 %R				Aroclor-1260	29-135 %R
Matrix Spike Duplicate	1 per ≤ 20 samples	Aroclor-1016	0-15 %RPD	Flag outliers	EPA CLP RAS Laboratory GC/ECD Technician	Precision	Aroclor-1016	0-15 %RPD
		Aroclor-1260	0-20 %RPD				Aroclor-1260	0-20 %RPD
Laboratory Control Sample	all samples	Aroclor-1016	50-150 %R	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	Aroclor-1016	50-150 %R
		Aroclor-1260	50-150 %R				Aroclor-1260	50-150 %R
Surrogate	all samples	30-150%R		Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory GC/ECD Technician	Accuracy	30-150%R	
Field Duplicate	1:20 samples	NA		Discuss in final deliverable	Task Leader	Precision	RPD ±35%	

**QAPP Worksheet #28-15**  
**QC Samples Table**

<b>Matrix</b>	Soil
<b>Analytical Group</b>	Target Analyte List Inorganics – Metals
<b>Concentration Level</b>	Low/Medium (mg/kg)
<b>Sampling SOP(s)</b>	SERAS SOP #2012
<b>Analytical Method/SOP Reference</b>	ISM02.2
<b>Sampler's Name</b>	McBurney, French, Wagner
<b>Field Sampling Organization</b>	SERAS
<b>Analytical Organization</b>	EPA CLP RAS Laboratory
<b>No. of Sample Locations</b>	TBD

Lab QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Preparation Blank	1 per $\leq 20$ samples	No constituent > CRQL	Suspend analysis until source rectified; redigest and reanalyze affected samples	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	No constituent > CRQL
Spike	1 per $\leq 20$ samples	75-125%R*	Flag outliers	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	75-125%R*
Duplicate	1 per $\leq 20$ samples	$\pm 20\%$ RPD**	Flag outliers	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Precision	$\pm 20\%$ RPD**
Post-Digestion Spike	after any analyte (except Ag) fails spike %R	75-125%R	Flag outliers	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	75-125%R
Interference Check Sample [ICP Analysis Only]	beginning of each run	Within $\pm$ (CRQL + true value) or $\pm 20\%$ of true value, whichever is greater	Check calculations and instruments, reanalyze affected samples	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Sensitivity	Within $\pm$ (CRQL + true value) or $\pm 20\%$ of true value, whichever is greater

\*except when the sample concentration is greater than 4 times the spike concentration, then disregard the recoveries; no data validation action taken

\*\*except when the sample and/or duplicate concentration is less than 5 times the CRQL, then  $\pm$  CRQL.

**QAPP Worksheet #28-15**  
**QC Samples Table**

<b>Matrix</b>	Soil
<b>Analytical Group</b>	Target Analyte List Inorganics- Metals [cont'd]
<b>Concentration Level</b>	Low/Medium (mg/kg)

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<b>Sampling SOP(s)</b>		SERAS SOP #2012				
<b>Analytical Method/SOP Reference</b>		ISM02.2				
<b>Sampler's Name</b>		McBurney, French, Wagner				
<b>Field Sampling Organization</b>		SERAS				
<b>Analytical Organization</b>		EPA CLP RAS Laboratory				
<b>No. of Sample Locations</b>		TBD				
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Laboratory Control Sample	1 per $\leq$ 20 samples	70-130%R	Suspend analysis until source rectified; redigest and reanalyze affected samples	EPA CLP RAS Laboratory ICP-AES/ICP-MS Technician	Accuracy	70-130%R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 35%

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**QAPP Worksheet #28-16**

**QC Samples Table**

<b>Matrix</b>	Soil					
<b>Analytical Group</b>	Target Analyte List Inorganics –Total Mercury					
<b>Concentration Level</b>	Low/Medium (mg/kg)					
<b>Sampling SOP(s)</b>	SERAS SOP #2012					
<b>Analytical Method/SOP Reference</b>	ISM02.2 – Cold Vapor Atomic Absorption (CVAA)					
<b>Sampler's Name</b>	McBurney, French, Wagner					
<b>Field Sampling Organization</b>	SERAS					
<b>Analytical Organization</b>	EPA CLP RAS Laboratory					
<b>No. of Sample Locations</b>	TBD					
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Preparation Blank (PB)	1 per $\leq$ 20 samples	No analyte > CRQL	Suspend analysis; redigest and reanalyze	EPA CLP RAS Laboratory Technician	Accuracy	No analyte > CRQL
Duplicate Sample	1 per $\leq$ 20 samples	$\pm$ 20% RPD	Flag outliers	EPA CLP RAS Laboratory Technician	Precision	$\pm$ 20% RPD
Spike Sample	1 per $\leq$ 20 samples	75 – 125 %R	Flag outliers	EPA CLP RAS Laboratory Technician	Accuracy	75 – 125 %R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 35%

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### QAPP Worksheet #28-17

#### QC Samples Table

<b>Matrix</b>	Soil					
<b>Analytical Group</b>	Target Analyte List Inorganics – Total Cyanide					
<b>Concentration Level</b>	Low/Medium (mg/kg)					
<b>Sampling SOP(s)</b>	SERAS SOP #2012					
<b>Analytical Method/SOP Reference</b>	ISM02.2 – Colorimeter or Spectrophotometer					
<b>Sampler's Name</b>	McBurney, French, Wagner					
<b>Field Sampling Organization</b>	SERAS					
<b>Analytical Organization</b>	EPA CLP RAS Laboratory					
<b>No. of Sample Locations</b>	TBD					
<b>Lab QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
Preparation Blank (PB)	1 per $\leq$ 20 samples	No analyte > CRQL	Suspend analysis; redigest and reanalyze	EPA CLP RAS Laboratory Technician	Accuracy	No analyte > CRQL
Duplicate Sample	1 per $\leq$ 20 samples	$\pm$ 20% RPD	Flag outliers	EPA CLP RAS Laboratory Technician	Precision	$\pm$ 20% RPD
Spike Sample	1 per $\leq$ 20 samples	75 – 125 %R	Flag outliers	EPA CLP RAS Laboratory Technician	Accuracy	75 – 125 %R
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 35%

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**QAPP Worksheet #28-18**  
**QC Samples Table**

Matrix	Soil					
Analytical Group	GRO					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2012					
Analytical Method/ SOP Reference	Katahdin SOP #CA-316					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	Katahdin					
No. of Sample Locations	TBD					
QC Sample:	Frequency/Number					
Method Blank (MB)	1 per batch of samples extracted	<Practical Quantitation Limit (PQL)	Investigate source of contamination	Analyst	Accuracy/Bias (Contamination)	No analyte >RL
Laboratory Control Sample (LCS)/Laboratory Control Sample Duplicate (LCSD)	1 per batch of samples extracted	%R = Within laboratory's established control chart limits	Reprep and reanalyze or document in case narrative	Analyst	Accuracy/Bias	%R = Within control chart limits
Matrix Spike (MS)	1 per batch of samples extracted	%R = Within laboratory's established control chart limits	If LCS is OK, narrate. If LCS and MS/MSD out, reprep the samples	Analyst	Accuracy/Bias	%R = Within control chart limits

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**QAPP Worksheet #28-18**  
**QC Samples Table**

Matrix	Soil
Analytical Group	GRO
Concentration Level	Low
Sampling SOP	SERAS SOP #2012
Analytical Method/ SOP Reference	Katahdin SOP #CA-316
Sampler's Name	McBurney, French, Wagner
Field Sampling Organization	SERAS
Analytical Organization	Katahdin
No. of Sample Locations	TBD

<b>QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
MS/Matrix Spike Duplicate (MSD) or Sample and duplicate	1 per batch of samples extracted	RPD $\pm$ 50% (MS/MSD) RPD $\pm$ 20% (sample and duplicate)	If LCS and MS/MSD out, reprep the samples. Evaluate sample for matrix interference	Analyst	Precision	RPD $\pm$ 50% (MS/MSD) RPD $\pm$ 20% (sample + Dup)
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 35%

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**QAPP Worksheet #28-19  
QC Samples Table**

Matrix	Soil					
Analytical Group	DRO/ORO					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2012					
Analytical Method/ SOP Reference	Katahdin SOP #CA-315					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	Katahdin					
No. of Sample Locations	TBD					
QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Method Blank	1 per batch of samples extracted	No analyte >RL	Investigate source of contamination	Analyst	Accuracy/Bias	No analyte >RL
LCS	1 per batch of samples extracted	%R = Within control chart limits	Reprep and reanalyze or document in case narrative	Analyst	Accuracy/Bias	%R = Within control chart limits
MS	1 per batch of samples extracted	%R = Within control chart limits	If LCS is OK, narrate. If LCS and MS/MSD out, reprep the samples	Analyst	Accuracy/Bias	%R = Within control chart limits

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**QAPP Worksheet #28-19**  
**QC Samples Table**

Matrix	Soil
Analytical Group	DRO/ORO
Concentration Level	Low
Sampling SOP	SERAS SOP #2012
Analytical Method/ SOP Reference	Katahdin SOP #CA-315
Sampler's Name	McBurney, French, Wagner
Field Sampling Organization	SERAS
Analytical Organization	Katahdin
No. of Sample Locations	TBD

<b>QC Sample:</b>	<b>Frequency/Number</b>	<b>Method/SOP QC Acceptance Limits</b>	<b>Corrective Action</b>	<b>Person(s) Responsible for Corrective Action</b>	<b>Data Quality Indicator (DQI)</b>	<b>Measurement Performance Criteria</b>
MS/MSD or sample and duplicate	1 per batch of samples extracted	RPD $\pm$ 50% (MS/MSD) RPD $\pm$ 20% (sample + Dup)	If LCS and MS/MSD out, reprep the samples. Evaluate sample for matrix interference	Analyst	Precision	RPD $\pm$ 50% (MS/MSD) RPD $\pm$ 20% (sample + Dup)
Field Duplicate	1:20 samples	NA	Discuss in final deliverable	Task Leader	Precision	RPD $\pm$ 35%

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### QAPP Worksheet #28-20 QC Samples Table

Matrix	Soil					
Analytical Group	Cr(VI)					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2012					
Analytical Method/ SOP Reference	Katahdin SOP #CA-625-06					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	Katahdin Analytical					
No. of Sample Locations	24					
QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 in 20	RPD ±35%	Document, report	Task Leader	Precision	RPD ±35%
LCS	1 per digestion batch of 20 or fewer samples	%R = 80-120%	Investigate source of problem; re- digest & re- analyze batch	Analyst	Accuracy	%R = 80-120
Soluble & Insoluble Pre-digestion Matrix Spike	1 per digestion batch of 20 or fewer samples	R ±25% of true value, if sample <4x spike added	Correct problem and re- homogenize, re- digest and re- analyze	Analyst	Accuracy	R ±25% of true value, if sample <4x spike added
Laboratory Duplicate	1 per digestion batch of 20 or fewer samples	RPD ±20%, if both the sample and duplicate are ≥ four times the PQL	Flag results	Analyst	Precision	RPD ±20%, if both the sample and duplicate are ≥ four times the PQL
Method Blank	One per batch of 20 samples/same matrix	< RL	Re-prep, re- analyze	Analyst	Accuracy/Bias	< RL

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**QAPP Worksheet #28-20**  
**QC Samples Table**

Matrix	Soil					
Analytical Group	Cr(VI)					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2012					
Analytical Method/ SOP Reference	Katahdin SOP #CA-625-06					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	Katahdin Analytical					
No. of Sample Locations	24					
QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Post-digestion matrix spike	1 per digestion batch of 20 or fewer samples	R $\pm$ 15% of true value, if sample <4x spike added	If check indicates interference, dilute and re- analyze sample	Analyst	Accuracy	R $\pm$ 15% of true value, if sample <4x spike added

**QAPP Worksheet #28-21**  
**QC Samples Table**

Matrix	Soil					
Analytical Group	TEL					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2012					
Analytical Method/ SOP Reference	TestAmerica SOP #BF-MB-010					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	TestAmerica					
No. of Sample Locations	TBD					
QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate	1 in 20	NA	Document, report	Task Leader	Precision (Field)	RPD: $\pm 35\%$
MS	1 in 20	Within control chart limits	Limits are advisory; frequent occurrences require investigation	Analyst	Accuracy/Bias	Within control chart limits
MS/MSD	1 in 20	Within control chart limits	Limits are advisory; frequent occurrences require investigation	Analyst	Precision	Within control chart limits
LCS	1 in 20	Within control chart limits	Reanalyze. If still failing, reextract and reanalyze batch. If high bias and samples are non- detect, report sample results	Analyst	Accuracy/Bias	Within control chart limits

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**QAPP Worksheet #28-21**  
**QC Samples Table**

Matrix	Soil					
Analytical Group	TEL					
Concentration Level	Low					
Sampling SOP	SERAS SOP #2012					
Analytical Method/ SOP Reference	TestAmerica SOP #BF-MB-010					
Sampler's Name	McBurney, French, Wagner					
Field Sampling Organization	SERAS					
Analytical Organization	TestAmerica					
No. of Sample Locations	TBD					
QC Sample:	Frequency/ Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Surrogates	Every Sample	Within control chart limits	Re-inject and/or reanalyze	Analyst	Accuracy/Bias	Within control chart limits
Method Blank	1 in 20	<RL	Investigate source of contamination, take and document corrective actions prior to sample analysis	Analyst	Accuracy/Bias Contamination	<RL
Internal Standards	Each sample	50-200%	Re-inject to confirm	Analyst	Accuracy/Bias	50-200%

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### QAPP Worksheet #28-22 QC Samples Table

Matrix	Soil
Analytical Group	Metals (FPXRF)
Concentration Level	Site Specific
Sampling SOP	SERAS SOP #2012
Analytical Method/ SOP Reference	SERAS SOP #1720
Sampler's Name	McBurney, French, Wagner
Field Sampling Organization	SERAS
Analytical Organization	SERAS
No. of Sample Locations	TBD

QC Sample:	Frequency/Number	Method/SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Sample Preparation Duplicate	Every 10-20 samples	Site specific (typically RPD < 50%)	NA (generally indicates sample homogeneity problem)	Analyst	Precision	Same as Method/SOP QC Acceptance Limits
Zero Check Sample	Pre-operation check	< Reporting Limit	Repeat, if continues to fail, check SRMs and/or send in for factory service or calibration	Analyst	Sensitivity	Same as Method/SOP QC Acceptance Limits
Precision Check Sample(s)	Every 10 samples	RSD < 20%	Calculated after site activities completed; Qualify data if > 20%	Analyst	Precision	Same as Method/SOP QC Acceptance Limits
Certified Reference Standard(s)	Pre-operation check and every 10-20 samples	Element results typically within +/- 20% of true values for concentrations at least 5-times the RL	Repeat. If continues to fail, send in for factory service/or calibration	Analyst	Accuracy/Bias	Same as Method/SOP QC Acceptance Limits

TBD – to be determined per Project.

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**QAPP Worksheet #29**  
**Project Documents and Records Table**

<b>Sample Collection Documents and Records</b>	<b>On-site Analysis Documents and Records</b>	<b>Off-site Analysis Documents and Records</b>	<b>Data Assessment Documents and Records</b>	<b>Other</b>
Chain of Custody Records Sample Labels Custody Seals Borehole Logs Site Logbooks Site Photos & templates Field Change Forms (If required) Well Sampling Logs Survey Logs	CPT/ROST Data CPT/ROST Run Logs Field XRF Run Logs Field XRF Results	Metals Soil and GW Results VOC Soil and GW results SVOC Soil and GW results PCB Soil and GW results Pesticides Soil and GW Results CrVI Soil and GW Results TEL Soil and GW Results GRO/ORO/DRO Results Instrument printouts Data Review Records Analytical Results Preventative Maintenance Logs Final Visualization Report	UFP-QAPP Verification Checklist Validation Check Records Peer Review Records Data Assessment Forms	Technical Memorandum SCRIBE Database Cross Sections Work Plan QAPP HASP

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### QAPP Worksheet #30 Analytical Services Table

<b>Matrix</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Sample Location/ID Numbers</b>	<b>Analytical SOP</b>	<b>Data Package Turnaround Time</b>	<b>Laboratory/Organization (Name and Address, Contact Person and Telephone Number)</b>	<b>Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)</b>
Soil	VOCs		See Worksheet #18	SOM02.2	2 Weeks	CLP Designated Laboratory TBD	
	SVOCs		See Worksheet #18	SOM02.2	2 Weeks	CLP Designated Laboratory TBD	
	Metals		See Worksheet #18	ISM02.2	2 Weeks	CLP Designated Laboratory TBD	
	PCBs		See Worksheet #18	SOM01.2	2 Weeks	CLP Designated Laboratory TBD	
	Pesticides		See Worksheet #18	SOM01.2	2 Weeks	CLP Designated Laboratory TBD	
	CrVI		See Worksheet #18	EPA SW846-7196	2 Weeks	Katahdin Labs 600 Technology Way Scarborough, ME 04074 207-874-2400	
	GRO/ORO/DRO		See Worksheet #18	EPA SW846-8015	2 Weeks	Katahdin Labs 600 Technology Way Scarborough, ME 04074 207-874-2400	
	TEL		See Worksheet #18	EPA SW846-8270	2 Weeks	Katahdin Labs 600 Technology Way Scarborough, ME 04074 207-874-2400	(subcontracted to TestAmerica-Buffalo)
GW	VOCs		See Worksheet #18	SOM02.2	2 Weeks	CLP Designated Laboratory TBD	

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**QAPP Worksheet #30**  
**Analytical Services Table**

<b>Matrix</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Sample Location/ID Numbers</b>	<b>Analytical SOP</b>	<b>Data Package Turnaround Time</b>	<b>Laboratory/Organization (Name and Address, Contact Person and Telephone Number)</b>	<b>Backup Laboratory/Organization (Name and Address, Contact Person and Telephone Number)</b>
	SVOCs		See Worksheet #18	SOM02.2	2 Weeks	CLP Designated Laboratory TBD	
	Metals		See Worksheet #18	ISM02.2	2 Weeks	CLP Designated Laboratory TBD	
	PCBs		See Worksheet #18	SOM01.2	2 Weeks	CLP Designated Laboratory TBD	
	Pesticides		See Worksheet #18	SOM01.2	2 Weeks	CLP Designated Laboratory TBD	
	CrVI		See Worksheet #18	EPA SW846-7196	2 Weeks	Katahdin Labs 600 Technology Way Scarborough, ME 04074 207-874-2400	
	GRO/ORO/DRO		See Worksheet #18	EPA SW846-8015	2 Weeks	Katahdin Labs 600 Technology Way Scarborough, ME 04074 207-874-2400	
	TEL		See Worksheet #18	EPA SW846-8270	2 Weeks	Katahdin Labs 600 Technology Way Scarborough, ME 04074 207-874-2400	(subcontracted to Test America-Buffalo)

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**QAPP Worksheet #31**  
**Planned Project Assessments Table**

<b>Assessment Type</b>	<b>Frequency</b>	<b>Internal or External</b>	<b>Organization Performing Assessment</b>	<b>Person(s) Responsible for Performing Assessment (Title and Organizational Affiliation)</b>	<b>Person(s) Responsible for Responding to Assessment Findings (Title and Organizational Affiliation)</b>	<b>Person(s) Responsible for Identifying and Implementing Corrective Actions (Title and Organizational Affiliation)</b>	<b>Person(s) Responsible for Monitoring Effectiveness of (Title and Organizational Affiliation)</b>
Peer review	With each deliverable	Internal	SERAS	Peer Review Team, SERAS	Jon McBurney, SERAS TL	Jon McBurney, SERAS TL	Deborah Killeen, SERAS QA/QC Officer
Laboratory Accreditation Audit	Every 2 years	External	NELAP accrediting agency	Regulatory Agency	QAO, Katahdin Analytical	Laboratory Operations, Katahdin Analytical	NELAP Accrediting Authority
Laboratory Audit Performance Evaluation Samples	Twice/Year	External	PT Provider	PT Provider	QAO, Katahdin Analytical	Laboratory Operations, Katahdin Analytical	Deborah Killeen, QA/QC Officer, SERAS
Laboratory Accreditation Audit	Annual	Internal	SERAS	QAO, Katahdin Analytical	Laboratory Operations, Katahdin Analytical	Laboratory Operations, Katahdin Analytical	QAO, Katahdin Analytical
CLP ASSESSMENTS????							

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**QAPP Worksheet #32**  
**Assessment Findings and Corrective Action Responses**

<b>Assessment Type</b>	<b>Nature of Deficiencies Documentation</b>	<b>Individual(s) Notified of Findings (Name, Title, Organization)</b>	<b>Timeframe of Notification</b>	<b>Nature of Corrective Action Response Documentation</b>	<b>Individual(s) Receiving Corrective Action Response (Name, Title, Org.)</b>	<b>Timeframe for Response</b>
Peer Review	Directly on deliverable	Jon McBurney, TL/SERAS	Prior to deliverable due date	Comments directly on deliverable	Jon McBurney, TL, SERAS	Prior to deliverable due date
Field Observations	Logbook	Jon McBurney, TL/SERAS	Immediately	Logbook	Jon McBurney, TL, SERAS	Within one business day of deviation
Deviations from QAPP	Field Change Form	Jon McBurney, TL/SERAS	Immediately	Field Change Form	Jon McBurney, TL, SERAS Deborah Killeen, QA/QC Officer, SERAS	Immediately
External Lab Performance Audits	Audit Report	Deborah Killeen, QA/QC Officer, SERAS	Within 30 Days	Corrective Action Plan	Regulatory Agency	Within 30 Days
External Lab Performance Audits	Audit Report	QAO, Katahdin Analytical	Within 30 Days	Corrective Action Plan	Regulatory Agency	Within 30 Days

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**QAPP Worksheet #33**  
**QA Management Reports Table**

<b>Type of Report</b>	<b>Frequency (Daily, weekly, monthly, quarterly, annually, etc.)</b>	<b>Projected Delivery Date(s)</b>	<b>Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)</b>	<b>Report Recipient(s) (Title and Organizational Affiliation)</b>
Technical Report	Monthly	20th of the month following performance period	TL/SERAS	ERT Project Officer and WAM
QA Report	Quarterly	February, May, August, November	QA/QC Officer/SERAS	ERT Quality Coordinator and ERT Project Officer

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**QAPP Worksheet #34**  
**Verification (Step I) Process Table**

<b>Verification Input</b>	<b>Description</b>	<b>Internal/ External</b>	<b>Responsible for Verification (Name, Organization)</b>
Technical Memorandum	Deliverable will be reviewed to verify that transcription errors are not present.	I	SERAS Peer review team
Completeness Check	Review of planning documents, sampling documents and external reports, as applicable, usign the UFP-QAPP checklist.	I	Jon McBurney, SERAS TL
Chain of Custody Record	Reviewed for accuracy and completeness	E	SERAS TL Katahdin Sample Receiving, Katahdin Analyst CLP Designated Laboratory Sample Receiving Analyst
Laboratory Data Package	Reviewed for completeness	I/E	Katahdin Analyst SERAS QA/QC Chemist CLP Designated Laboratory Analyst Region 6 QA/QC Chemist
Analytical Report	Reviewed for Accuracy	Internal	Peer Review Team
CPT/ROST Results	Reviewed for accuracy and completeness	Internal	SERAS TL
Raw data	Verify that all acquired data have been backed-up, either to a shared drive or external storage media (e.g., compact disc).	Internal	J. McBurney/SERAS
Model assessment	Review model theory, mathematical structure and required input parameters to verify that the model will perform the required tasks in order to meet the objectives of the study.	External	Modeling Subcontractor
Modeling and related calculations	Verify correct data input	Internal	J. McBurney/SERAS

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**QAPP Worksheet #35**  
**Validation (Steps IIa and IIb) Process Table**

<b>Step IIa/IIb</b>	<b>Validation Input</b>	<b>Description</b>	<b>Responsible for Validation (Name, Organization)</b>
IIa	SOPs	Ensure that the sampling methods/procedures outlined in the QAPP were followed and any deviations noted	SERAS TL, WAM
IIb	SOPs	Determine potential impacts from noted/approved deviations, in regard to PQOs.	SERAS QA/QC Chemists, ERT WAM
IIa	Chains of custody	Examine COC forms against QAPP and laboratory contract requirements (e.g., analytical methods, sample identification, etc.).	Katahdin Analytical Lab personnel, CLP Designated Lab Personnel SERAS TL, SERAS QA/QC Chemist
IIa	Laboratory data package	Examine packages against QAPP and laboratory contract requirements, and against COC forms (e.g., holding times, sample handling, analytical methods, sample identification, data qualifiers, QC samples, etc.).	Katahdin Analytical Lab Personnel, Region 6 QA/QC Chemist SERAS QA/QC Chemist
IIb	Laboratory data package	Determine potential impacts from noted/approved deviations, in regard to PQOs. Examples include PQLs and QC sample limits (precision/accuracy).	SERAS QA/QC Chemist SERAS QA/QC Officer Region 6 QA/QC Chemist Region 6 QA/QC Officer

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**QAPP Worksheet #36**  
**Validation (Steps IIa and IIb) Summary Table**

<b>Step IIa/IIb</b>	<b>Matrix</b>	<b>Analytical Group</b>	<b>Concentration Level</b>	<b>Validation Criteria</b>	<b>Data Validator (title and organizational affiliation)</b>
IIb	Soil, Water	CrVI	Low	SERAS SOP #1017, <i>Data Validation Procedure for Routine Inorganic Analysis</i>	SERAS QA/QC Group
IIb	Soil, Water	TEL	Low	SERAS SOP #1016, <i>Data Validation Procedure for Routine Organic Analysis</i>	SERAS QA/QC Group
IIb	Soil, Water	VOCs	Low	In accordance with EPA Region 6 Data Validation Guidelines	Region 6 CLP QA/QC Group
IIb	Soil, Water	SVOCs	Low	In accordance with EPA Region 6 Data Validation Guidelines	Region 6 CLP QA/QC Group
IIb	Soil, Water	PCBs and Pesticides	Low	In accordance with EPA Region 6 Data Validation Guidelines	Region 6 CLP QA/QC Group
IIb	Soil, Water	Metals, Hg, CN	Low	In accordance with EPA Region 6 Data Validation Guidelines	Region 6 CLP QA/QC Group

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☒ Worksheet Not Applicable (State Reason) EPA Region 6 is responsible for assessing the usability of the data

### **QAPP Worksheet #37**

#### **Usability Assessment**

Summarize the usability assessment process and all procedures, including interim steps and any statistics, equations, and computer algorithms that will be used:
Describe the evaluative procedures used to assess overall measurement error associated with the project:
Identify the personnel responsible for performing the usability assessment:
Describe the documentation that will be generated during usability assessment and how usability assessment results will be presented so that they identify trends, relationships (correlations), and anomalies:

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## APPENDIX A

Field Operations Procedure for CPT and ROST Laser-Induced Fluorescence (Fugro Consultants)

UFP-QAPP for Wilcox – Revision 1

November 2015

**FUGRO CONSULTANTS, INC.**

**FIELD OPERATIONS PROCEDURE**

**INTEGRATED**

**CONE PENETRATION TESTING (CPT)**

**and**

**RAPID OPTICAL SCREENING TOOL (ROST™)**

**LASER - INDUCED FLUORESCENCE**

**( CPT/ROST™)**

## **1.0 Scope and Application**

### **1.1 Introduction**

This Standard Operating Procedure (SOP) describes the field procedures used to conduct a subsurface in-situ petroleum hydrocarbon investigation with the Rapid Optical Screening Tool (ROST™) – Laser Induced Fluorescence currently offered by Fugro Consultants, Inc. The screening tool can be deployed either integrated with a Cone Penetration Testing (CPT) System or as a stand-alone screening tool. In the former configuration, both lithologic and subsurface contamination information are collected, while in the latter case, only contaminant information is gathered.

### **1.2 Application**

This SOP is applicable to the rapid investigation of subsurface aromatic hydrocarbon contamination at hazardous waste sites.

### **1.3 Personnel and Training**

Implementation of this SOP is restricted to use by, or under the supervision of, field technicians experienced in the use of CPT/ROST™ technology and familiar with cone penetration testing, soil boring installation, grouting techniques, and laser-induced fluorescence technology. Fugro will ensure all personnel are qualified and have received training relevant to the tools, materials and equipment, and instruments used in the testing procedures.

## **2.0 Method Summary**

### **2.1 Initial Site Survey**

Prior to mobilization of the ROST™ equipment and crew to the jobsite, the client should conduct a thorough survey of the proposed testing locations to locate underground utilities and possible obstacles that may hinder smooth operations or may cause damage to the ROST™ probe.

If proposed testing locations are located on pavement, client should determine type and thickness of pavement. Generally, asphalt pavement less than 3" thick can be pre-punched with a special tool prior to pushing with the ROST™ probe. However, if the pavement is concrete, a concrete coring subcontractor should be used to core through the pavement, prior to the arrival of the test vehicle and crew for best productivity.

Furthermore, the client, in conjunction with Fugro, should determine beforehand if it is necessary to hand-auger proposed test locations to a certain depth to further clear the locations for utilities. This is highly recommended for refineries, existing or former tank farms, residential areas, or for any site where old buried structures may exist. Again, this should be completed prior to the arrival of the test vehicle and crew for best productivity.

### **2.2 Method of Deployment**

ROST™ testing is typically conducted integrated with CPT. In this configuration, the screening tool is attached to the back-end of an electrical cone, usually a piezocone. In this setup, soil behavior characteristics together with pore pressure measurements and contaminant information are acquired. The integrated CPT/ROST™ can be deployed using a CPT rig; either a truck-mounted or an All Terrain Vehicle (ATV)-mounted unit. These units are specially built vehicles that have self-contained electrical, hydraulic and climate control systems and range in weight from 15 to 30 tons.

ROST™ testing can also be conducted as a stand-alone unit, deployed with either a CPT rig or a Geoprobe. In these configurations, only contaminant information is acquired.

### **2.3 Integrated CPT/ ROST™ Testing**

In this configuration, CPT is performed simultaneously with each ROST™ sounding. The ROST™ fiber optic cable pair is attached to the CPT cable and strung into the cone rods as one integrated CPT/ ROST™ umbilical. The depth counting mechanism for both systems is synchronized through a PCUM tap connected to the CPT and ROST™ systems.

### **2.4 Stand-Alone ROST™ Testing**

Stand-Alone ROST™ Testing can be deployed using either a CPT rig or a Geoprobe. In either case, only the ROST™ fiber optic cable pair is strung into the cone rods. The depth counting mechanism is accomplished through the CPT PCUM system synchronized with the ROST system.

### **2.5 Rapid Optical Screening Tool (ROST™)**

Fugro Consultants' ROST™ - LIF system consists of the following devices:

#### **2.5.1 Spectroscopy Rack**

- 2.5.1.1 Nd:YAG Laser System Model CFR 200 driving a tunable Dye laser
- 2.5.1.2 Monochromator that selects desired wavelengths
- 2.5.1.3 Photomultiplier tube that converts light into electrical signals
- 2.5.1.4 Dye and coolant circulation pumps
- 2.5.1.5 Laser power supply
- 2.5.1.6 Monitoring and control components

#### **2.5.2 Control Rack**

- 2.5.2.1 Personal Computer and peripherals
- 2.5.2.2 High Speed Tektronix TDS 4014B digital oscilloscope

#### **2.5.3 Fiber optic cable pair with appropriate connectors**

#### **2.5.4 LIF sub containing a barrel, mirror and a sapphire window**

### **2.6 Decontamination**

Two methods of decontaminating the push rods and the ROST™ assembly are used:

- 2.6.1 Rubber wipers installed inside the guide sleeve casing act as “scrubbers” and wipe the rods clean as these are being retracted after the completion of a test. This method is adequate for sites where minimal to moderate amounts of lighter hydrocarbon contaminants, such as gasoline, diesel or jet fuel, have been encountered.
- 2.6.2 A high-pressure steam cleaning unit, attached to the bottom of the guide sleeve and known as the “under-the-truck” decontamination unit, is used to wash each rod section and the ROST™ assembly as these are retracted after the completion of a test. This method is applicable where moderate to large amounts of contaminants, specially the heavier hydrocarbon types like creosote or tar, have been encountered.

Dependent upon the push depth and number of locations, a small volume of decontamination fluid is generated at each location when using the “under-the-

truck” decontamination unit. The decontamination fluid is collected in a five-gallon bucket from under the truck and transferred to a DOT certified steel drum or other approved container.

## **2.7 Borehole Abandonment and Grouting**

Grouting is performed to ensure that vertical cross contamination does not occur in the penetration and borehole locations. To accomplish this, a mixture specified by the client, typically bentonite slurry or bentonite/cement mixture is pumped into the open borehole through a tremie pipe or through an appropriate sized plastic tubing or through grout rods as these are retracted.

## **3.0 Method Limitations**

### **3.1 Truck-Mounted Cone Penetration Testing Access Limit**

The Fugro truck-mounted CPT rig is a modified 6-axle heavy-duty truck. The dimensions of the truck require a minimum access width of 9 feet and a height clearance of 16 feet. Some sites, or areas of sites, might not be accessible to a vehicle the size of the CPT truck.

### **3.2 Cone Penetration Advancement Limits**

The CPT sensors and sampling tools may be difficult to advance in subsurface media containing cemented sands and clays, buried debris, gravel units, cobbles, boulders, and shallow bedrock. As with all intrusive site characterization methods, it is extremely important that all underground utilities and structures are located using reliable geophysical equipment operated by trained professionals before undertaking activities at a site.

### **3.3 Response to Different Petroleum Hydrocarbons**

The relative response of the ROST™ - LIF sensor depends on the specific product type being screened. Age of contamination and lithology also affect the response. Generally, light-end hydrocarbons in the gasoline to diesel range in clean sands fluoresce easily compared to heavy-end hydrocarbons in the tar to crude oil residuals range.

### **3.4 Matrix Effects**

The in-situ fluorescence response of the LIF sensor to hydrocarbon compounds is also sensitive to variations in the soil matrix. Matrix properties that affect LIF sensitivity include soil grain size, mineralogy, moisture content, and surface area. Each of these factors influences the relative amount of contaminant that is adsorbed on or absorbed into the soil. Only the relative fraction of contaminant that is optically accessible at the window of the probe can contribute to the fluorescence signal.

### **3.5 Spectral Interferences**

The ROST™ -LIF sensor is sensitive to any material that fluoresces when excited with ultraviolet wavelengths of light. Although intended to specifically target petroleum hydrocarbons, the excitation energy produced by the LIF system’s laser may cause other naturally occurring substances to fluoresce as well.

## **4.0 Quality Assurance/Quality Control**

### **4.1 Overview**

Data generated by field crews during the ROST™ investigation, whether conducted as integrated with CPT or as a stand-alone system, is reviewed by personnel possessing the required skills and experience necessary to evaluate and validate the results. All field data are transmitted to Fugro's main office where it is checked for accuracy of measurements, processed and the results reviewed prior to the release of a Final Report.

### **4.2 Fugro ROST™ - LIF QA/QC**

Initial system setup will require the calibration of the ROST™ unit. Details of the ROST™ –LIF QA/QC are given in Appendix A.

### **4.3 Fugro CPT QA/QC**

Initial system setup requires the calibration of the CPT system prior to testing on each location. Details of the CPT QA/QC are outlined in Appendix B.

## **5.0 Waste Disposal**

Decontamination fluids and other investigation derived wastes (IDW) generated during ROST™ testing are properly containerized, staged, labeled, and managed in accordance with the project work plan. The volume of waste generated is minimized whenever applicable.

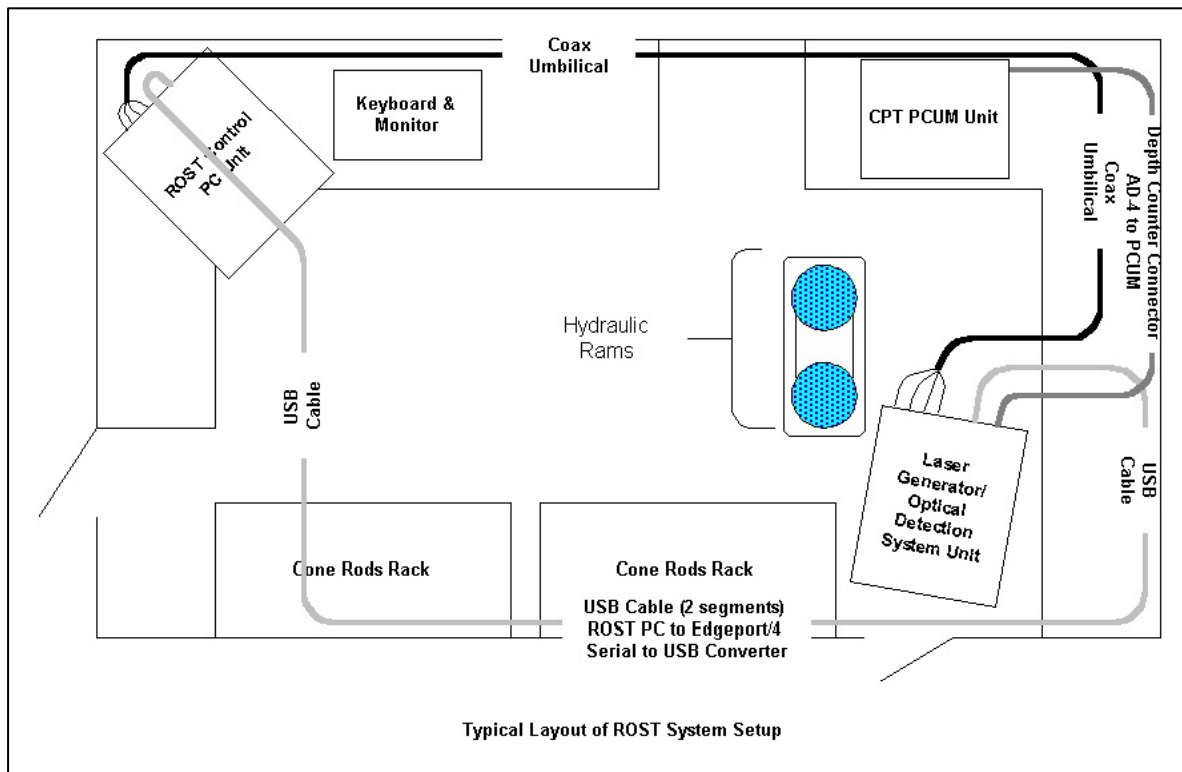
## **6.0 Health and Safety**

A site-specific safety and health plan is developed for ROST™ and related ROST™ activities. All field personnel are required to attend safety meetings scheduled by the client and/or undergo further training as specified by the client's Health and Safety Plan requirements.

**APPENDIX A**  
**RAPID OPTICAL SCREENING TOOL (ROST™)**  
**LASER INDUCED FLUORESCENCE**  
**FIELD OPERATIONS PROCEDURE**

**SYSTEM SETUP**

A typical setup of the ROST system in the CPT rig is illustrated in the following figure:



This setup requires  $\pm 25$  foot coax cables (4 lengths) bundled as one umbilical and 2 x 15 foot segments of the Active USB Cables.

The coax cable must be low-noise type and the umbilical is strung on the left side of the rig on hooks and/or attached to the roof by Velcro. The coax cable must be stretched out – not coiled – to prevent signal interference.

The USB cables are attached to roof by Velcro and should be positioned as far away as possible from the Coax umbilical. This type of USB cables are available only in 15 foot segments, so it is necessary to connect 2 of these in order to complete the connection.

## 1.0 ASSEMBLING THE LIF BARREL/CPT CONE

- 1.1 Make sure the following components are clean and free of any oil-based contaminants:
  - a. LIF barrel – wash withalconox + water, rinse with deionized (DI) water and either air-dry it or blow dry with canned air spray (be careful not to tilt or shake the can).
  - b. LIF bullet – spray DI water directly into the bullet end and blow dry with the air spray. Avoid wiping it with alcohol – it may affect the epoxy seal.
  - c. Mirror – spray a burst of canned air directly to the mirror surface, place a drop of alcohol on it, then blow dry it. Inspect mirror surface – if specks of dust are still visible on the mirror surface, spray it again, immerse an optical cleaning paper with alcohol and gently wipe the mirror surface. Do not press it too hard, since this would cause permanent damage to the mirror.
  - d. Sapphire window – inspect the sapphire closely for scratches or cracks specially along the edges adjacent to the rubber seal. If heavily scratched or if any cracks are present, discard the window. Clean with water andalconox, rinse with DI water and allow to dry or blow dry with canned air spray. To clean the inside, use optical cleaning paper immersed in alcohol and blow dry.  
Inspect the threads and clean with brush. Ensure that the threads are free of dirt or other material that may affect the seal when screwed onto the LIF sub.
- 1.2 Replace the O-rings on the bullet and mirror, O-ring size = 006.
- 1.3 Insert the bullet end of the fiber optic/CPT cable into the LIF sub (the barrel assembly can only be inserted from the back-end of the sub).
- 1.4 Warm-up the laser unit and run it until normal operating temperatures are achieved, typically 10 to 15 minutes with the laser running at mid range pump level.
- 1.5 Insert the mirror and the bullet into the barrel.
- 1.6 Place a window (either long or short) with an O-ring (size 012) onto the barrel hole opening.
- 1.7 Set oscilloscope to 5mv by turning the knob on the Vertical menu scale and observe the signal – this is the background level. Manipulate the mirror until diminished background levels are displayed. Check location of the UV light on the window by placing a piece of white paper on it. Ideally, the UV light should be off center, close to the edge of the window. Once minimal background levels are achieved, tighten mirror set screws at the same time observing any changes in the background signal. It may be necessary to readjust the mirror's position and orientation as you do this before tightening it.
- 1.8 Set oscilloscope to 100mv, again by turning the knob on the Vertical menu scale, and place M1 on window. Note waveform on oscilloscope and adjust bullet until an optimum signal is displayed by moving the bullet in and out and by twisting it clockwise and counter-clockwise in small increments.  
Once maximum M1 waveform is displayed, (ideally it should occupy at least  $\frac{1}{2}$  to  $\frac{3}{4}$  of the oscilloscope display), tighten the bullet set screws, again observing any changes in the waveform and readjusting the bullet's position and orientation, as needed.
- 1.9 Connect the integrated fiber optic/CPT cable to the cone and assemble the LIF sub. It is advisable to wrap Teflon tape on the window threads as it can help prevent leakage. Take care not to get excess Teflon tape in the path of the UV light.
- 1.10 Screw window on; typically, long windows need 1 O-ring and short ones need 2 O-rings if the sub being used is fairly new. However, for older subs that have been used, only short

windows with 1 O-ring can be used. It is best to test which size of window and O-ring has the best fit for a particular sub before assembly. Observe the background levels at 5mv on the oscilloscope while screwing the window on. If the background level changes after tightening the window, realign the mirror and the bullet in the barrel again until diminished background levels are achieved.

- 1.11 Screw LIF sub to the lead rod and tighten. Be sure to tighten the rods, not the sub, to avoid twisting the cables.

## 2.0 WARM – UP PROCEDURES

Let the generator run for at least 5 minutes before turning anything on. This should stabilize the power output and minimize any surges that may occur with a cold-start of the generator.

- 2.1 Turn ROST™ unit and the PC on and let it run for at least 15 minutes.

- 2.1.1 On the control PC Desktop, click on “**ROST Project**” icon to go to the **ROST Menu**:

- 2.1.2 Choose **Colorization** and click on the appropriate **Default**:

Use **Default for Common Fuels** if lighter hydrocarbon contaminants, such as gasoline, jet fuel or diesel is suspected in the particular job location.

Use **Default for Tars & Creosotes** if any of these two products are the primary products of concern.

- 2.1.3 Choose **Log & Print Setup** and enter **Operator Name**, **Job Number**, **Client Name**, and **Site Name** in the appropriate boxes and other pertinent information in the **Log Notes**. The system will save the information and automatically update the time and date for every sounding done for the duration of the project (or until the information entered is changed). However, this menu may be accessed at any time to add or change Log Notes or Comments during the course of the day (or for the duration of the project).

**NOTE:** Do not change any of the information stored while running a test. Doing so would delete the data currently being recorded by the system.

- 2.1.4 Choose **Depth** and check if the appropriate depth counting mechanism is chosen.

**NOTE:** The typical depth counting mechanism used is the **AD4**, which is a USB device directly connected from the ROST™ system to the CPT PCUM depth counter. However, in some instances, it may be necessary to use the **PCU Tap**, which is a serial connection between the ROST™ system and the CPT laptop.

- 2.1.5 Choose **Hardware** to go to the data acquisition menu. Check to see if the green lights are on for the **Oscilloscope**, **Monochromator**, **AD4** (or for appropriate depth counting method) and for the **Doubling Crystal**. If any of these lights are off, the system has detected a fault (on the device with the green light off), which must be corrected before proceeding.

- 2.2 Check the laser and Dye oven temperatures (after the system has been running for at least 15 minutes):

- 2.2.1 For the laser oven, hit “**FF**” on the menu and check if **OVEN** is **OK**. Then, press **Main Menu** on the keypad.

- 2.2.2 For the Dye oven, the normal operating temperature is **40°**. This can be seen by lifting the Spectroscopy Rack cover slightly while the laser generating unit is off and observing the temperature display on the LCD on the oven control box.

- 2.2.3 If both ovens are **OK**, turn the laser on; hit **"RUN"**, then **"D - ON"**; **"E - ON"**, and set pump energy between **8.0 to 8.6** (press **"B"**, choose **energy level**, then **"ENTER"**).  
**NOTE:** If the oven temperatures are less than the normal operating temperatures, wait another 5 minutes before turning the laser on.
- 2.3 Check Dye energy level on the oscilloscope – choose **Monitor Dye Energy** or hit **ALT-D**. If it is still low (barely discernible on the oscilloscope screen), let the laser run for another 15 minutes to allow maximum generation of Dye energy (or until you see a decent signal on the oscilloscope).
- 2.4 If the Dye energy output is ok, home the crystal by clicking on **Home** (or **ALT-H**). Normally, this is done at the start of the project, say on the first day; however, this procedure can be done on a daily basis, if necessary.  
**NOTE:** Homing the crystal is an optional procedure and can be bypassed if the unit is operating normally.
- 2.5 Optimize the Dye energy by clicking on **Optimize** (or **ALT-O**). Ideally, the waveform on the screen display on the ROST™ menu should be a smooth bell-shaped curve with the red dot at or near the center crosshair. If this is not the case, optimize the Dye energy until the ideal waveform is achieved. Once optimizing is completed, do an initial M1 calibration.  
**NOTE:** The new software automatically updates the energy readings after the completion of the Optimize cycle so there is no need to click on **Update** anymore.
- 2.6 Set the oscilloscope to 100Mv by turning the knob on the Vertical menu scale. Place the M1 on the window and choose **Acquire M1 Reference Emitter** (or **ALT-M**) in the ROST™ Command sub-menu. Press **ENTER** when the reminder message appears. Note and record the M1 value in pVs.
- 2.8 Do an M1 calibration at different pump energies, noting the values acquired with different pump energy levels. Normally, start with a pump energy that would give an M1 reading between 20,000 to 25,000 pVs – this should give a wide range of M1 values through the day without increasing or decreasing the pump energy in large increments. For repeatability and consistency of the calibration, the M1 calibration value should not increase by more than  $\pm 3,000$  pVs between test locations.  
**NOTE:** The Dye and YAG energy levels can be influenced by several variables. If the system is being started in cold weather, it may take a while before enough YAG energy is generated to produce reasonable Dye energy. On the other hand, the energy output can decrease if the laser gets too hot.  
 The condition of the YAG head and the flashlamp can also affect it. Regular maintenance of the YAG head would keep it in optimal operating condition. The number of shots the flashlamp has affects its ability to generate YAG energy. According to the laser manufacturer, the flashlamp starts to deteriorate after producing 20 million shots, which causes it to generate less amount of energy. This condition greatly reduces the YAG energy generated and consequently, the Dye energies.

Once the laser generating unit has stabilized and the M1 values generated from a chosen pump energy level becomes consistent (i.e., identical M1 values are obtained after doing several calibrations using the same pump energy setting), the warm-up procedures are complete and the system is ready to use.

### 3.0 DATA ACQUISITION PROCEDURES

At this point, the pump energy required to generate the optimal YAG and Dye energies that would give optimal M1 calibration values suitable for the specific job have been determined from the warm-up procedures. As a rule of thumb, M1 values in the 20,000 to 25,000 pVs range are suitable for screening for lighter hydrocarbons in the gasoline to diesel range; for heavier

hydrocarbons in the creosote to petroleum residues range, M1 values > 25,000 pVs should be used.

**NOTE:** Higher pump energy settings are required to generate higher M1 values; this could cause the laser generator to overheat during the course of the day. It is recommended that when high pump energy levels are used, the laser generator should be turned off after the completion of each sounding to allow the system to cool off.

### 3.1 Calibration Procedures:

- 3.1.1 Position the rig over the desired test location.
- 3.1.2 Ensure that the sapphire window is clean – it may be necessary to clean the window with DI water and wiped with a clean paper towel.
- 3.1.3 Optimize YAG and Dye energy levels using pump energy level determined from the warm-up procedures. If YAG and Dye values do not conform with the values derived from the warm-up procedures, adjust pump energy level accordingly.
- 3.1.4 Acquire M1 reading. Ensure that M1 Reference Solution device is properly set on laser sub/sapphire window.
- 3.1.5 Record YAG, Dye and M1 values together with Test Location Identification Number, Time and other pertinent information regarding the location.

### 3.2 Data Logging Procedures:

- 3.2.1 Switch to “**Depth**” on left hand side of ROST™ Window.  
Ensure that the **Zero Depth Count = 0**; otherwise, click on “**Zero Out**”.
- 3.2.2 Click on “**Record Log**”.
  - 3.2.2.1 Choose “**Yes**” on dialog to save file
  - 3.2.2.2 Choose appropriate folder where data will be stored.  
**NOTE:** It is best to create a folder in the C:\Rost directory for the specific job where the data will be stored. This can be done during the warm-up procedures and can be named using the Job Number together with the client name and description of the location.  
Example: 03-1128\_retec\_hynes.
  - 3.2.2.3 Enter Hole Identification Number in appropriate box
  - 3.2.2.4 Click on “**Save**” – or hit “**Enter**”.
  - 3.2.2.5 Click on “**Yes**” when prompted by Depth Encoder Reset dialog box.  
**NOTE:** Depth in Feet = 1.25 when running integrated CPT/ROST™  
Depth in Feet = 0 when running stand-alone ROST™
  - 3.2.2.6 Note Total Fluorescence when cone is still above ground level and enter in Daily Log as starting background level.
  - 3.2.2.7 Synchronize depth with CPT Unit.
- 3.2.3 Start push; observe ROST™ depth values when pushing is stopped and compare with CPT depth.  
**NOTE:** ROST™ system counts depth in millimeters and references depth values from ground level; i.e., depth values displayed are negative.
- 3.2.4 Upon completion of sounding, click on “**Terminate Log**”, check depths for both CPT and ROST™, note and record ending background level and turn off the laser generator if moving to the next location will take more than 15 minutes. Otherwise, leave the laser running and plot the results.

### 3.3 Waveform Analyses and Plotting Data

- 3.3.1 Switch to “**Log & Print Setup**” on left hand side of ROST™ window.
- 3.3.2 Enter appropriate depth and fluorescence intensity values on log.
- 3.3.3 Choose depths for waveform analyses by running cursor on FVD plot, stopping at the desired depth and clicking on Plot 1 (through 4) on Log & Print Setup window. A maximum of 4 points can be analyzed. Typically, high hits are chosen.

- 3.3.4 Click on **“Create JPG”** to save the plot in jpeg format (for later viewing and/or printing) and save in the same folder as the ROST™ dataset.
- 3.3.5 Click on **“Print”** to print the FVD log with waveform analyses.
- 3.3.6 While printing, switch window to **“Hardware”** and optimize YAG and Dye energy levels. This will give a quality control check on laser energy levels upon completion of a sounding and will give an indication of system conditions.

### 3.4 Saving Data:

The current version of the ROST™ system has 6 outputs, namely:

#### 3.4.1 Log Files

The \*.log files are stored separately in the Activity Logs directory on the C:\ drive that is created and maintained automatically once the system is turned on. This contains a detailed log of all the activity that takes place each day when the ROST™ system is running.

The following files are stored in a separate folder in the ROST Data directory:

#### 3.4.2 FVD Files

Fluorescence vs. Depth files (\*.FVD) contain the full data matrix as follows:

Row 1, Column 1 is a zero that serves as a placeholder.  
 Row 1, Column 2 to the last column is the time vector in nanoseconds.  
 Row 2, Column 1 is a negative 9 string serving to indicate M1 Reference Emitter Waveform  
 Row 2, Column 2 to the last column is the voltage readings of the M1 Reference Emitter Waveform  
 Row 3 to the last row, Column 1, is the depth of each ROST™ measurement.  
 Row 3 to the end row, Column 2, to the last column are all the voltages of the ROST™ waveforms acquired at each depth.

#### 3.4.3 AVD Files

Area vs. Depth files (\*.AVD) are abbreviated files that are most often given to clients along with the INFO files. Typically, client would be interested in Columns 1 and 2 only.

Format is as follows:

Column 1 is the depth in feet (or meters).  
 Column 2 is total fluorescence represented as a % of M1 (to normalize data).  
 Column 3 is relative signal strength (area) of Channel # 1 (340 nm).  
 Column 4 is relative signal strength (area) of Channel # 2 (390 nm).  
 Column 5 is relative signal strength (area) of Channel # 3 (440 nm).  
 Column 6 is relative signal strength (area) of Channel # 4 (490 nm).  
 Column 7 is a 32-bit color code number based on color scheme used for the test.

#### 3.4.4 INFO Files

The Information files (\*.INFO) are self-explanatory. These contain all the information that are stored from each test that would enable printing, viewing and analyses to take place at a later date even without having access to the Operator's Notes. ROST™ software uses this to update the Information Panel when loading previously acquired ROST™ logs.

#### 3.4.5 PST File

The PST file (\*.pst) is a legacy file that is used to allow the older MATLAB software to view, print and analyze FVD logs acquired using the new software. It is the M1 waveform stored as:

Column 1 – Depth  
Column 2 – Voltage

#### 3.4.6 JPG File

This is a copy of the plot generated in jpeg format. It is a record of the original plotting parameters selected for a particular test location and is used in determining final plotting parameters needed for the Final Report.

It is a good practice to save the day's data in a removable medium. For the current ROST™ System, this is done through a CD burning software program, called Creatr50. It is recommended that a rewritable (CD-RW) be used; in this manner, the disc can be used multiple times by simply erasing the contents of the previous day before recording the current day's data. At the end of the project, the CD will contain all the data gathered for the project.

To use Creatr50, follow the following steps:

1. Click on the “**Creatr50**” icon on the desktop.
2. On upper pane, choose file to save on disc; note the size of the file.
3. Highlight the file for copying and click on “**Add**” or simply drag the file name down to the lower box.
4. Click on “**Record**”.
5. Once recording is completed, exit Creatr50 program. Do not save any configuration when prompted.

After recording is completed. Check the disc contents by clicking on the “**My Computer**” icon, choose the appropriate drive for the CD burner and double click. Note the size of the file and compare to the size noted in Step 2. If these do not match, some of the data may have been skipped during the recording process and it may be necessary to copy the files again.

### 3.5 Powering Down the System

At the end of the workday, power down the ROST™ system in the following sequence:

- 3.5.1 Exit the ROST™ Data Acquisition software
- 3.5.2 Turn off the PC
- 3.5.3 Turn off the oscilloscope
- 3.5.4 Turn off the laser generator toggle switch.
- 3.5.5 Wait for at least 20 seconds, and turn off the ROST™ main power switch.

**NOTE:** Do not turn off the power supply (generator) or the main switch on the laser generator while the ROST™ PC is still “on”.

## 4.0 MISCELLANEOUS INFORMATION

As stated before, it is important to maintain a range of  $\pm 3,000$  pVs ( $\pm 10\%$ ) of the M1 calibration levels referred to the first and last push for a day. This will ensure repeatability and consistency of data gathered for that particular day. To achieve this, it is necessary to consider the following factors:

- 4.1** The M1 calibration is a function of the Dye energy levels; the greater the Dye energy generated, the more light is available to read the M1.
- 4.2** Dye energy is a function of YAG; higher YAG energy levels generate more Dye energies.
- 4.3** The amount of the UV light that goes out to the fiber optic cable may be influenced by the position of the launch fiber/translation chuck. It is also influenced by the condition of the window, mirror and fiber optic cable..
- 4.4** Generation of UV light is low when the laser unit is cold and deteriorates as the unit gets hotter. This means that the laser unit has to be warmed up adequately in the mornings (or at start of day) and the temperature must be constantly monitored during the day.

For example, if the pump is set at 8J with YAG=30, Dye=80 and M1 = 24,000 pVs on one hole, and on the next location the Dye goes down to 60 with the YAG constant at 30 using the same pump energy of 8J, then it is expected that the M1 calibration value will be lower than the previous reading. In this instance, it may be necessary to bump up the pump energy to  $\pm 8.3\text{J}$  or so. However, if the same (or nearly the same) M1 value is obtained even after bumping up the pump energy to ever increasing levels, this indicates a problem within the system. This type of incident may be caused by any of the following:

- 4.5** Misalignment of UV light going to the launch fiber end. It may be necessary to check condition of launch fiber/translation chuck and/or launch fiber cable..
- 4.6** Laser unit getting hot – usually this happens when the laser generator has been running continuously for more than an hour or so. To correct this, turn the unit off, let it cool down for 15 – 20 minutes before starting the next hole.
- 4.7** Window may be contaminated by moisture which may have leaked into the LIF assembly through either the sapphire window or through the LIF sub-assembly/cone rods connection. In this case, it is necessary to break the cone apart and clean everything, and then start over with the hardware checks outlined at the start of this manual.

## APPENDIX B

### CONE PENETRATION TESTING FIELD OPERATIONS PROCEDURE

#### 1.0 Summary of Test Method

A penetrometer assembly with a conical point having a 60° apex angle and a cone base area of 10 cm<sup>2</sup> or 15 cm<sup>2</sup> is advanced through the soil at a constant rate of 2 centimeters per second. The force on the conical point (cone) required to penetrate the soil is measured by strain gages at a minimum of every 2 centimeters of penetration. Stress is calculated by dividing the measured force (total cone force) by the cone base area to obtain cone resistance,  $q_c$ .

A friction sleeve is present on the penetrometer immediately behind the cone tip, and the force exerted on the friction sleeve is measured by strain gages attached to load cells at the top and bottom of the sleeve assembly, at a minimum of every 2 cm of penetration. Stress is calculated by dividing the measured force by the surface area of the friction sleeve to determine friction sleeve resistance,  $f_s$ .

Many penetrometers are capable of measuring dynamic pore pressure induced during advancement of the penetrometer tip using an internal pressure transducer. These penetrometers are called “piezocones.” The piezocone is advanced at a rate of 2 centimeters per second, and readings are taken at a minimum of every 2 centimeters of penetration. The dissipation of excess pore pressure can be monitored by stopping penetration, unloading the push rod, and recording pore pressure as a function of time. When pore pressure becomes constant, it is measuring the equilibrium value or piezometric head at that depth.

#### 2.0 Significance and Use

Tests performed using CPT methods provide a detailed record of penetrometer results, which are used for the evaluation of site stratigraphy, homogeneity and depth to firm layers, voids or cavities, other discontinuities, and correlations with geotechnical and hydrogeological properties of soils. When properly performed at suitable sites, the test provides a rapid means for determining subsurface conditions.

CPT methods provide data used for estimating engineering properties of soil intended to help with the design and construction of earthworks, foundations for structures, and the behavior of soils under static and dynamic loads.

CPT methods test the soil in situ and soil samples are not obtained. The interpretation of the results from the test methods provide estimates of the types of soil penetrated. Engineers may obtain soil samples from parallel borings for correlation purposes since the results of these tests are empirical in nature and yield results regarded as behavior type but not actual grain size.

#### 3.0 Limitations of Use

Refusal, deflection, or damage to the penetrometer assembly may occur in coarse-grained soil deposits with maximum particle sizes that approach or exceed the diameter of the cone. Partially lithified and/or cemented deposits may cause refusal, deflection, or damage to the penetrometer assembly.

Standard push rods can be damaged or broken under extreme load conditions. The amount of force that push rods are able to sustain is a function of the unrestrained length of the push rods and the weak links in the push rod-penetrometer tip string, such as push rod joints and push rod-penetrometer assembly connections. The force at which rods may break is a function of the equipment configuration and ground conditions during penetration. Excessive rod deflection is the

most common cause for rod breakage during deep pushes in dense material with soft overlying soil.

## **4.0 Equipment**

Equipment utilized in conducting Cone Penetrometer Testing include:

1. Electric Standard Cone (CPT) to measure tip and sleeve resistances and probe inclination
2. Piezocone (CPTu) to measure tip and sleeve resistances, probe inclination and dynamic pore pressure
3. Cone rods with pre strung electrical 10-pin copper cable
4. Data Acquisition System including the Analog-Digital (A/D) Conversion System and a data logging laptop computer
5. A self-contained CPT rig that contains the hydraulic pushing system, a power supply unit and other tools, equipment and materials necessary

### **4.1 Electric Cone Penetrometers**

Fugro Consultants, Inc. utilizes electric cone penetrometers, available in either a 10 cm<sup>2</sup> or 15cm<sup>2</sup> cone base area that exceed the standards set forth by ASTM-D5778-95, now currently under review and revision. Technical details and specifications of Fugro's Cone Penetrometers are given in Appendix BB.

### **4.2 Cone Rods**

Fugro's CPT cone rods are manufactured from high tensile strength steel and have a cross sectional area adequate to sustain, without buckling, the thrust required to advance the penetrometer tip. Prior to testing, a 10-pin electrical cable is prestrung through the cone rods and is connected by a crossover cable to the Data Acquisition System.

Push rods are supplied in 1- meter lengths and must be secured together to bear against each other at the joints to form a rigid-jointed string. The deviation of push rod alignment from a straight axis should be held to a minimum, especially in the push rods near the penetrometer tip, to avoid excessive directional penetrometer drift.

Generally, when a 1-m long push rod is subjected to a permanent circular bending resulting in 1 to 2 millimeter (mm) of center axis rod shortening, the push rod should be discarded. This corresponds to a horizontal deflection of 2 to 3 mm at the center of bending. The locations of push rods in the string should be varied periodically to avoid permanent curvature.

Standard 20-metric ton high tensile strength steel push rods with 36-mm OD, 16-mm ID, and a mass per unit length of 6.65 kg/m are used.

### **4.3 Data Acquisition System**

The basic data acquisition system utilized by Fugro Consultants, Inc. in conducting CPT Testing consists of an electronic signal conditioner, a three-pen analog strip chart recorder, a portable laptop computer, and a printer.

The data acquisition system converts the analog signal from the cone penetrometer to a digital signal, which is monitored, recorded and presented in near-real time on the laptop computer. As stipulated in ASTM D-5778-95, a three-pen strip chart recorder monitors

and displays the analog signals directly from the cone penetrometer in real-time. This provides an accurate recording of the collected data, regardless of the analog to digital conversion. Upon completion of testing, the strip chart record of the analog readings is compared to the digital readings recorded on the laptop computer. This comparison of analog to digital signals provides a quality control system that ensures accurate and highly reliable data including the initial and final calibration zeros.

Information collected during a push are stored digitally as ASCII formatted data on magnetic disks readable by MS-DOS or Windows-based programs that read text files. The data files include project description and location, operator, data format information and other pertinent information about the sounding.

Following each push, data collected with a standard CPT cone are presented in a graphical format. The log includes:

1. cone resistance plot in tons/ft<sup>2</sup> (TSF),
2. friction sleeve resistance plot in tons/ft<sup>2</sup> (TSF), and
3. friction ratio plot in %

versus depth below ground surface in feet.

For data collected with a piezocone, the log includes, in addition to the above, an additional plot of pore pressure in tons/ft<sup>2</sup> (TSF), versus depth in feet.

A variety of plotting parameters are available for uniform presentation of data. As stipulated in the ASTM standard, the vertical axis is designated for the depth while the horizontal axis displays the magnitude of the test values recorded. Final plotting scales are determined after all the tests are completed, and takes into consideration maximum test values and depths recorded for the project.

#### **4.4 CPT Rig**

A primary component of any CPT system is the CPT rig. Fugro currently owns and operates ten (10) truck mounted CPT units, two (2) ATV-mounted units, and two (2) skid mounted units. The CPT rigs have self contained electrical, hydraulic, and climate control systems and range in weight from 15 to 30 tons. Except for the skid-mounted units, the rigs have hydraulic jacking systems to lift and level the pushing platform. The “dead weight” of the rigs provides the reaction weight necessary for advancing the CPT tools, eliminating the need for time-consuming earth anchoring.

### **5.0 Calibration**

Fugro's cone penetrometer manufacturing and calibration procedures include ISO 9001, ASTM D-5778-95, and European cone penetration standards. The calibration tests include load testing over the full range of output for each cone. Cones are tested and calibrated for the following:

#### **Mechanical Calibration**

- Cross-talk Check
- Dimension Check
- Seal / O-Ring Check

#### **Electronic Calibration**

- Temperature Effect
- Pre and Post Test Voltage Readings (zeros)
- Full Scale Output Load Reading

- Pore Pressure effect on tip and friction readings
- Pore Pressure Transducer calibration

Fugro's cone penetrometer calibration zeros are checked and verified before and after each sounding. Periodic full-scale calibration is likewise conducted according to the Quality Assurance and Quality Control procedures as specified in ASTM D-5778-95.

## **6.0 Test Procedure**

Prior to beginning a sounding, a site survey is performed to ensure hazards such as underground utilities will not be encountered. The rig is positioned over the location of the sounding and the leveling jacks are lowered to raise the machine mass off the rig's suspension system. The hydraulic rams of the penetrometer thrust system are set to as near vertical as possible by adjusting the leveling jacks. Once the rig is set level, the following procedures are done:

### **6.1 Standard Cone Penetrometers**

1. Power up the penetrometer tip and data acquisition system according to the manufacturer's recommendations, typically 15 to 30 minutes, prior to use.
2. Measure the average diameter of the tip and sleeve to be sure that the sleeve is slightly larger than the tip ( $\approx 0.01$  in.) and both are within specifications; i.e., average tip diameter  $> 1.69$  inches (in) OD and average sleeve diameter  $> 1.70$  in. OD.
3. Obtain initial zero readings for the cone in an unloaded condition at a temperature as close as possible to ground conditions.
4. Record on the project data sheet other pertinent information such as Project Number, Date and Time, Cone Identification, Strip Chart Recorder ranges and starting point of each test.
5. Advance the cone into the soil at a rate of approximately 2 centimeters per second. The depth, tip resistance, sleeve friction and probe inclination are continuously recorded at 2 centimeter intervals.
6. During the progress of sounding, monitor tip and sleeve forces continuously for signs of proper operation. It is helpful to monitor other indicators such as ram pressure or probe inclination to ensure that damage will not occur if highly resistant layers or obstructions are encountered. Probe inclination is a particularly useful indicator of imminent danger to the system.
7. At the end of a sounding, extract the penetrometer tip, obtain a final set of zero readings of the unloaded cone, and check them against the initial zeros. Record initial and final baselines on all documents related to the sounding.
8. Inspect the cone assembly after each push for damage to the components or seals and replace parts as needed.

### **6.2 Piezocone Penetrometers :**

1. Assemble the piezo elements with all fluid chambers submerged in the de-aired medium used to prepare the elements. Flush all confined areas with fluid to remove air bubbles. Tighten the cone tip to effectively seal the flat surfaces.
2. If unsaturated soil is first penetrated and it is desired to obtain accurate dynamic pore pressure response once below the ground water, it may be necessary to prebore or sound a pilot hole to the water table. In many cases the piezocone fluid system may be cavitating during penetration through unsaturated soil or in dilating sand layers

below the water table, which can adversely affect dynamic response. As the cone is advanced deeper, the saturation levels may recover as air bubbles are driven back into solution according to Boyles Law. Evaluation of proper interpretation of dynamic response requires experience.

3. Inspect the cone assembly after each push for damage to the components or seals and replace parts as needed.

## **7.0 Quality Assurance and Quality Control**

As part of Fugro's QA procedures, readings from the cone penetrometer are recorded in both analog and digital formats. In addition, prior to each test, cone specific calibration factors are entered into the Data Acquisition System's signal conditioner, and zeros are measured and recorded prior to and upon completion of each sounding.

Upon completion of a project, the field data are transmitted electronically or by overnight mail to the main office in Houston, Texas, where it is processed, reviewed and finalized. The original, unprocessed data is stored in a large capacity, limited access storage medium where it is kept indefinitely for future reference as confidential records.

The integrity of the measurements are checked and verified to ensure that the logs generated are as accurate as possible. Rod spikes, which are generated naturally when the pushing is stopped such as when adding rods while advancing the sounding, are identified and edited out. These are displayed as negative spikes on the field generated CPT plot and when left uncorrected, may affect data integrity when further processing is done on the data.

The edited CPT plot is compared to the analog strip chart where corresponding peaks and troughs on both logs should match. Should any deviation beyond Fugro's accepted standards occur, the data is rejected and the hole is redone at Fugro's expense.

Prior to the release of the Final Report, the entire set of data is reviewed by a Senior Staff member. In this process, the reviewer conducts a thorough assessment of the data set checking its consistency and accuracy.

## APPENDIX BB

### FUGRO PENETROMETER TIPS DATA - TYPES FCKE

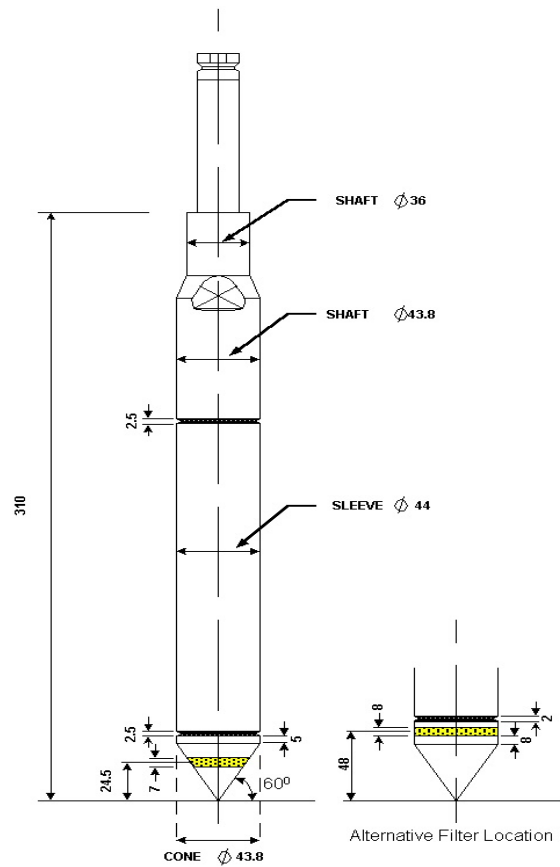
SPECIFICATIONS LOADCELLS		F5CKE	F10CKE	F7.5CKE & F15CKE
<b>CONE LOADCELL</b>				
Base Area	cm <sup>2</sup>	10	10	15
Apex Angle	DEG	60	60	60
Full Range	kN	50	100	150
Load Limit	kN	100	100	200
Effect of 10 bar water pressure	N	450	450	880
Output at zero load	mV	< ± 0.5	< ± 0.5	< ± 0.5
Full range output (FRO)	mV	10	10	10
Input resistance	ohm ca.	270	270	270
Output resistance	ohm ca.	240	240	240
Non linearity and hysteresis	%FRO	< 0.1	< 0.1	< 0.1
Calibration accuracy	%FRO	< 0.5	< 0.5	< 0.5
Rated bridge supply voltage	Volt	10	10	10
Maximum bridge supply voltage	Volt	15	15	15
Thermal zero shift	%FRO/10 <sup>0</sup> C	< 0.2	< 0.2	< 0.2
Thermal Sensitivity shift	%FRO/10 <sup>0</sup> C	< 0.1	< 0.1	< 0.1
Repeatability	%FRO	< 0.1	< 0.1	< 0.1
<b>SLEEVE + CONE LOADCELL</b>				
Sleeve Area	cm <sup>2</sup>	150	150	200
Full Range	kN	50	100	150
Load Limit	kN	100	100	200
Effect of 10 bar water pressure	N	300	300	280
Output at zero load	mV	< ± 0.5	< ± 0.5	< ± 0.5
Full range output	mV	10	10	10
Input resistance	ohm ca.	270	270	270
Output resistance	ohm ca.	240	240	240
Non linearity and hysteresis	%FRO	< 0.1	< 0.1	< 0.1
Calibration accuracy	%FRO	< 0.5	< 0.5	< 0.5
Rated bridge supply voltage	Volt	10	10	10
Maximum bridge supply voltage	Volt	15	15	15
Thermal zero shift	%FRO/10 <sup>0</sup> C	< 0.2	< 0.2	< 0.2
Thermal Sensitivity shift	%FRO/10 <sup>0</sup> C	< 0.1	< 0.1	< 0.1
Repeatability	%FRO	< 0.1	< 0.1	< 0.1
<b>GENERAL</b>				
Friction output at full range load of cone	%FRO	< 2		
Compensated temperature range	<sup>0</sup> C	- 10 to + 40		
Maximum temperature	<sup>0</sup> C	80		
Insulation resistance	10 <sup>8</sup> ohm	> 5		
Slope sensor built-in		on request		

**NOTES:** The friction sleeve is located immediately above the cone.

Standard delivery includes: cone, calibration sheet, and connector tube.

The accuracy during field use will depend on: field calibrations, treatment during testing, readout equipment, abrasion and maintenance.

## **TYPE F7.5CKEW/V**



### **DIMENSIONS**

<b>CONE BASE AREA</b>	(mm <sup>2</sup> )	: 1,500
<b>SLEEVE AREA</b>	(mm <sup>2</sup> )	: 20,000
<b>α FACTOR</b>	:	<b>0.59</b>

### **SPECIFICATIONS**

#### **CONE LOAD CELL**

- FULL SCALE RANGE	(kN)	: 75
- OVERLOAD CAPACITY	(kN)	: 200

#### **CONE PLUS SLEEVE LOAD CELL**

- FULL SCALE RANGE	(kN)	: 75
- OVERLOAD CAPACITY	(kN)	: 200

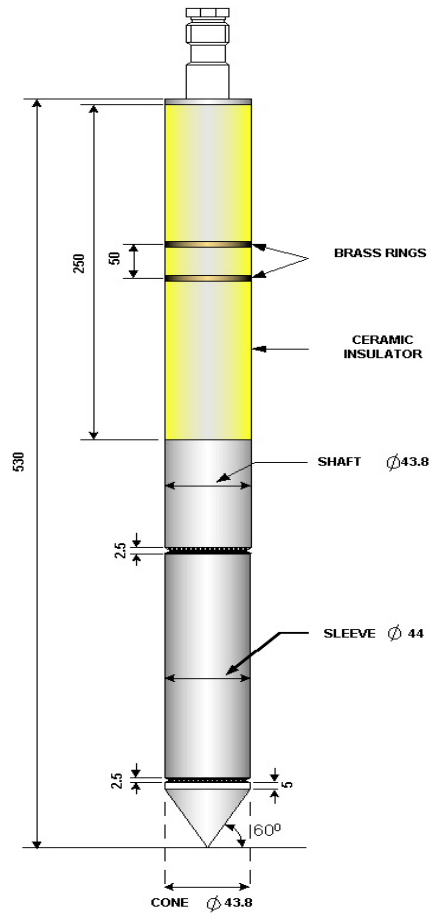
#### **PORE PRESSURE TRANSDUCER**

- FULL SCALE RANGE	(Mpa)	: 5.0
- BURST PRESSURE	(Mpa)	: 12.5

### **NOTES:**

1. LOAD CELLS/TRANSDUCERS MAY BE CALIBRATED FOR LOWER RANGES
2. UNEQUAL SLEEVE END AREAS
3. SUBTRACTION TYPE
4. ALL DIMENSIONS IN mm
5. BUILT-IN AMPLIFIERS
6. SLOPE SENSOR INCORPORATED
7. THREADED END : INTERNAL, CONICAL

## TYPE F7.5CKEG/V



### DIMENSIONS

CONE BASE AREA	(mm <sup>2</sup> )	: 1,500
SLEEVE AREA	(mm <sup>2</sup> )	: 20,000
α FACTOR		: 0.59

### SPECIFICATIONS

#### CONE LOAD CELL

- FULL SCALE RANGE	(kN)	: 75
- OVERLOAD CAPACITY	(kN)	: 200

#### CONE PLUS SLEEVE LOAD CELL

- FULL SCALE RANGE	(kN)	: 75
- OVERLOAD CAPACITY	(kN)	: 200

#### PORE PRESSURE TRANSDUCER

- FULL SCALE RANGE	(Mpa)	: 5.0
- BURST PRESSURE	(Mpa)	: 12.5

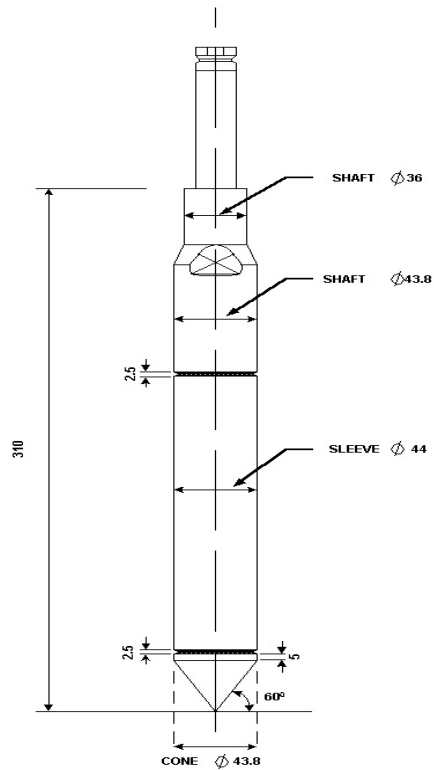
#### ELECTRICAL CONDUCTIVITY

- FULL SCALE RANGE	(S/m)	: 1.0
- MAXIMUM RANGE	(S/m)	: 5.0

### NOTES:

1. LOAD CELLS/TRNSDUCERS MAY BE CALIBRATED FOR LOWER RANGES
2. UNEQUAL SLEEVE END AREAS
3. SUBTRACTION TYPE
4. ALL DIMENSIONS IN mm
5. BUILT-IN AMPLIFIERS
6. SLOPE SENSOR INCORPORATED
7. THREADED END : EXTERNAL. M28 x 2

## **TYPE F7.5CKE/V**



### **DIMENSIONS**

<b>CONE BASE AREA</b>	<b>(mm<sup>2</sup>)</b>	<b>: 1,500</b>
<b>SLEEVE AREA</b>	<b>(mm<sup>2</sup>)</b>	<b>: 20,000</b>
<b>α FACTOR</b>		<b>: 0.59</b>

### **SPECIFICATIONS**

#### **CONE LOAD CELL**

<b>- FULL SCALE RANGE</b>	<b>(kN)</b>	<b>: 75</b>
<b>- OVERLOAD CAPACITY</b>	<b>(kN)</b>	<b>: 200</b>

#### **CONE PLUS SLEEVE LOAD CELL**

<b>- FULL SCALE RANGE</b>	<b>(kN)</b>	<b>: 75</b>
<b>- OVERLOAD CAPACITY</b>	<b>(kN)</b>	<b>: 200</b>

### **NOTES:**

1. LOAD CELLS/TRANSDUCERS MAY BE CALIBRATED FOR LOWER RANGES
2. UNEQUAL SLEEVE END AREAS
3. SUBTRACTION TYPE
4. ALL DIMENSIONS IN mm
5. BUILT-IN AMPLIFIERS
6. SLOPE SENSOR INCORPORATED
7. THREADED END : INTERNAL, CONICAL